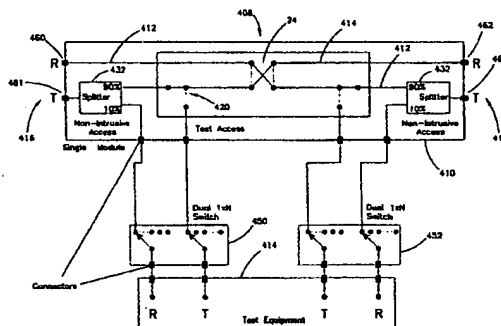


1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100 101 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 127 128 129 130 131 132 133 134 135 136 137 138 139 140 141 142 143 144 145 146 147 148 149 150 151 152 153 154 155 156 157 158 159 160 161 162 163 164 165 166 167 168 169 170 171 172 173 174 175 176 177 178 179 180 181 182 183 184 185 186 187 188 189 190 191 192 193 194 195 196 197 198 199 200 201 202 203 204 205 206 207 208 209 210 211 212 213 214 215 216 217 218 219 220 221 222 223 224 225 226 227 228 229 230 231 232 233 234 235 236 237 238 239 240 241 242 243 244 245 246 247 248 249 250 251 252 253 254 255 256 257 258 259 260 261 262 263 264 265 266 267 268 269 270 271 272 273 274 275 276 277 278 279 280 281 282 283 284 285 286 287 288 289 290 291 292 293 294 295 296 297 298 299 300 301 302 303 304 305 306 307 308 309 310 311 312 313 314 315 316 317 318 319 320 321 322 323 324 325 326 327 328 329 330 331 332 333 334 335 336 337 338 339 340 341 342 343 344 345 346 347 348 349 350 351 352 353 354 355 356 357 358 359 360 361 362 363 364 365 366 367 368 369 370 371 372 373 374 375 376 377 378 379 380 381 382 383 384 385 386 387 388 389 390 391 392 393 394 395 396 397 398 399 400 401 402 403 404 405 406 407 408 409 410 411 412 413 414 415 416 417 418 419 420 421 422 423 424 425 426 427 428 429 430 431 432 433 434 435 436 437 438 439 440 441 442 443 444 445 446 447 448 449 450 451 452 453 454 455 456 457 458 459 460 461 462 463 464 465 466 467 468 469 470 471 472 473 474 475 476 477 478 479 480 481 482 483 484 485 486 487 488 489 490 491 492 493 494 495 496 497 498 499 500 501 502 503 504 505 506 507 508 509 510 511 512 513 514 515 516 517 518 519 520 521 522 523 524 525 526 527 528 529 530 531 532 533 534 535 536 537 538 539 540 541 542 543 544 545 546 547 548 549 550 551 552 553 554 555 556 557 558 559 560 561 562 563 564 565 566 567 568 569 570 571 572 573 574 575 576 577 578 579 580 581 582 583 584 585 586 587 588 589 590 591 592 593 594 595 596 597 598 599 600 601 602 603 604 605 606 607 608 609 610 611 612 613 614 615 616 617 618 619 620 621 622 623 624 625 626 627 628 629 630 631 632 633 634 635 636 637 638 639 640 641 642 643 644 645 646 647 648 649 650 651 652 653 654 655 656 657 658 659 660 661 662 663 664 665 666 667 668 669 670 671 672 673 674 675 676 677 678 679 680 681 682 683 684 685 686 687 688 689 690 691 692 693 694 695 696 697 698 699 700 701 702 703 704 705 706 707 708 709 710 711 712 713 714 715 716 717 718 719 720 721 722 723 724 725 726 727 728 729 730 731 732 733 734 735 736 737 738 739 740 741 742 743 744 745 746 747 748 749 750 751 752 753 754 755 756 757 758 759 760 761 762 763 764 765 766 767 768 769 770 771 772 773 774 775 776 777 778 779 780 781 782 783 784 785 786 787 788 789 790 791 792 793 794 795 796 797 798 799 800 801 802 803 804 805 806 807 808 809 810 811 812 813 814 815 816 817 818 819 820 821 822 823 824 825 826 827 828 829 830 831 832 833 834 835 836 837 838 839 840 841 842 843 844 845 846 847 848 849 850 851 852 853 854 855 856 857 858 859 860 861 862 863 864 865 866 867 868 869 870 871 872 873 874 875 876 877 878 879 880 881 882 883 884 885 886 887 888 889 890 891 892 893 894 895 896 897 898 899 900 901 902 903 904 905 906 907 908 909 910 911 912 913 914 915 916 917 918 919 920 921 922 923 924 925 926 927 928 929 930 931 932 933 934 935 936 937 938 939 940 941 942 943 944 945 946 947 948 949 950 951 952 953 954 955 956 957 958 959 960 961 962 963 964 965 966 967 968 969 970 971 972 973 974 975 976 977 978 979 980 981 982 983 984 985 986 987 988 989 990 991 992 993 994 995 996 997 998 999 1000 1001 1002 1003 1004 1005 1006 1007 1008 1009 1010 1011 1012 1013 1014 1015 1016 1017 1018 1019 1020 1021 1022 1023 1024 1025 1026 1027 1028 1029 1030 1031 1032 1033 1034 1035 1036 1037 1038 1039 1040 1

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- For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.*



(57) Abstract: A fiber optic circuit provides signal access and monitoring. A module housing the circuit is mountable to a chassis. The module housing includes mounting flanges for mounting the module to the chassis; and a plurality of exposed adapters along at least one of the front and rear faces. Each of the plurality of adapters is connectable to a fiber optic connector external to the module. The plurality of adapters define first and second transmit signal ports and first and second receive signal ports. A receive signal pathway is between the first and second receive signal posts. A transmit signal pathway is between the first and second receive signal ports. A first switch, such as a 2x2 switch, is between the transmit and receive signal pathways wherein the switch has first and second states, the first state being a normal through state wherein the first and second transmit signal ports are in communication along the transmit signal pathway, and wherein the first and second receive signal ports are in communications along the receive signal pathway, and a loopback state wherein the first transmit signal and the receive signal port are in communication along a first loopback path along a portion of the transmit and receive signal pathways, and wherein the second transmit and receive signal ports are in communication along a loopback path along other portions of the transmit and receive signal pathways. A second 2x2 switch or a 1x2 switch allows access for testing with test equipment and a 1xN optical switch. The various switches can be remotely controlled.

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FIBER OPTIC CIRCUIT AND MODULE WITH SWITCH

Field of the Invention

The present invention relates to fiber optic circuits and modules for
5 fiber optic equipment.

Background of the Invention

The telecommunications and data transmission industries are rapidly
expanding their development of fiber optic transmission systems. Historically,
10 telecommunications signals and data have been transmitted over wire lines such as
twisted pair or coaxial cables. In order to accommodate higher signal rate speeds,
the industry is turning to increased use of fiber optic cables as the transmission
medium.

As the use of fiber optic cables increases, the need for peripheral
15 equipment has increased. For example, it is desirable to have access to a fiber optic
line for the purpose of either re-routing the line in the event of damage to the line or
to have access to the line for the purposes of monitoring or testing the line.

Fiber optic peripheral equipment for cable management, cable
storage, and connection capabilities are well known. The use of modular fiber optic
20 connector modules is known for performing so-called cross-connect applications.
U.S. Patent Nos. 5,432,875 and 5,363,465 to ADC Telecommunications, Inc.
concern fiber optic connector modules and chassis designs for receiving the modules
in cross-connect applications.

There is a continuing need for fiber optic circuits and systems which
25 provide optical signal routing, monitoring, and access capabilities.

Summary of the Invention

The present invention includes an optical circuit for connecting fiber
optic cables and/or equipment, including one or more switches in the optical circuit
30 for changing the optical signal paths of the circuit. The switch or switches can be
used to selectively link the optical signal paths to access terminals, such as for signal
testing, monitoring or re-routing. The optical circuit may allow for one or more of
the following functions for signals passing through the circuit: passing through of
the signals, non-intrusive monitoring of the signals, looping back of the signals
35 between the transmit and receive terminals, and splitting of the signals, such as in
combination with test equipment.

One circuit of the present invention includes two optical signal
pathways and a switch between the two signal pathways allowing normal pass

through of the signals along each signal pathway in one state, and looping back of the signals in a second state. Access to one or both of the signal pathways can be provided to the circuit by non-intrusive monitors, or switches, such as 1x2 switches or 2x2 switches.

5 Remote control of the one or more switches in the optical circuits of the present invention allows for remote test access, in one preferred system.

The optical circuits of the present invention can be housed in one or more housings, as desired. Modular housings allow for convenient assembly, use and maintenance of the system.

10 In accordance with the invention, one preferred embodiment includes one or more fiber optic modules which are mountable to a chassis for holding one or more modules. Each module may have a plurality of connection locations for coupling to fiber optic connectors. The connection locations are linked together by optical couplers within the module. Telecommunications cables and equipment are
15 connected to first sets of the connection locations of the modules. The modules may be used to cross-connect fiber optic equipment via patch cords between second sets of the connection locations, or the second sets of the connection locations may be connected together within a single module.

One preferred embodiment of the fiber optic module of the present
20 invention includes a first pair of adapters for connection to fiber optic connectors and a second pair of adapters for connection to further fiber optic connectors. The first and second pairs of adapters are connected by fiber optic signal pathways through the module. One adapter of each pair may define a transmit signal port, and the other adapter of each pair may define a receive signal port. The first pair of
25 adapters may be connected to a cable entering a customer's facility. The second pair of adapters may be cross-connected to another module at the customer's facility, or the adapters may be connected to other fiber optic equipment.

One preferred embodiment of the fiber optic module includes a first
30 switch between the first and second signal pathways wherein both pathways are in a straight pass through configuration when the switch is in a first state, and wherein both pathways are linked to form two loop back pathways through the module when the switch is in a second state. One preferred embodiment includes a 2x2 optical switch.

One further preferred embodiment of a fiber optic module includes a
35 third pair of adapters, such as for use in connecting to test or access equipment. A second switch links the third pair of adapters to either the transmit signal pathway or the receive signal pathway. The second switch has at least two states, wherein a first state of the second switch optically links one adapter of the third pair to the other

adapter of the third pair in a loop back configuration. A second state of the second switch optically links one adapter of the third pair of adapters to one of the adapters of the first pair, and the other adapter of the third pair is optically linked to the first switch. Splitters and monitor ports may be linked to the transmit and receive signal pathways in preferred embodiments.

In an alternative preferred embodiment, a single additional adapter may be provided, instead of the third pair of adapters, and a single 1x2 optical switch provided in either the transmit or receive signal pathways. The 1x2 switch optically isolates the third adapter in one state, and optically links the additional adapter to the first switch when the 1x2 switch is in a second state. Splitters and monitor ports may be linked to the transmit and receive signal pathways in preferred embodiments.

Further embodiments of the invention include an optical circuit including first and second pairs of connection locations, each pair defining a transmit signal connection location and a receive signal connection location. The transmit signal connection location of each pair is optically linkable through a signal path to the receive signal connection location of the other pair. One or more access connection locations are provided which are linkable to one of the signal paths through the circuit. One or more switches may be provided to selectively link the access connection location(s) to one of the signal paths. A first switch, such as a 2x2 switch, between the signal paths, and a second switch, such as a 1x2 or a 2x2 switch between one of the signal paths and the access connection location(s) are provided. The first and second pairs of connection locations defining the transmit and receive signal connection locations may be part of a single module or housing construction in a frame, rack or chassis, or they may be part of separate modules or housing constructions cross-connected together through optical signal pathways, such as patch cords or other optical links.

The circuits of the present invention may be used in a variety of applications, such as for looping back of signals, or for splitting signals in combination with test equipment.

Brief Description of the Drawings

In the drawings, wherein like reference letters and numerals indicate corresponding elements throughout the several views:

FIG. 1A is a schematic diagram of an optical circuit in accordance with the invention;

FIG. 1 is a schematic diagram of a first embodiment of a fiber optic access module in accordance with the present invention;

FIG. 2 is a schematic representation of various features which may be provided with various fiber optic access modules in accordance with the present invention;

FIG. 3 is a schematic representation of two fiber optic access modules cross-connected together, and showing various features which may be provided with the various fiber optic modules of the present invention;

FIG. 4 is a schematic diagram of a control system for remotely controlling the optical switches in the fiber optic access modules;

FIG. 5 is a perspective view of a chassis showing two fiber optic access modules mounted thereto;

FIG. 6 is a rear perspective view of the chassis and modules shown in FIG. 5;

FIG. 7 is a front view of the single circuit fiber optic access module;

FIG. 8 is a front perspective view of the module of FIG. 7;

FIG. 9 is a rear perspective view of the module of FIG. 7;

FIG. 10 shows two alternative fiber optic access modules cross-connected together, and connected to fiber optic test equipment;

FIG. 11 shows the two modules of FIG. 10 in a transparent or normal mode;

FIG. 12 shows the two modules of FIG. 10 in a loopback mode with respect to the fiber optic terminals;

FIG. 13 shows the two modules of FIG. 10 in a loopback mode with respect to the test equipment;

FIG. 14 shows the first module of FIG. 10 in a split loopback mode with respect to the test equipment;

FIG. 15 shows the second module of FIG. 10 in a split loopback mode with respect to the test equipment;

FIG. 16 shows both modules of FIG. 10 in the split loopback mode, as shown in FIG. 14 and 15;

FIG. 17 shows the first module of FIG. 10 in a split mode where the transmit signal of the second module is received by the test equipment connected to the first module;

FIG. 18 shows the second module of FIG. 10 in a split mode where the transmit signal of the first module is received by the test equipment connected to the second module;

FIG. 19 shows both modules of FIG. 10 in the split mode, as shown in FIGS. 17 and 18;

FIG. 20 shows both modules of FIG. 10 in a monitor mode with respect to the test equipment;

FIG. 21 is a schematic diagram of a second embodiment of a fiber optic access module including a 2x2 loopback switch, and a 1x2 split switch positioned in the transmit signal pathway;

FIG. 22 is a schematic representation of various options for the module of FIG. 21;

FIG. 23 is a schematic representation showing various options for two modules of the type shown in FIG. 22 cross-connected together;

FIG. 24 shows two fiber optic access modules cross-connected together of the type shown in FIG. 21, and also shown connected to fiber optic test equipment;

FIG. 25 shows a modification to one of the modules of FIG. 24, where a 2x2 switch has been eliminated;

FIG. 26 shows the two modules of FIG. 25 showing the loopback pathways for the primary signals;

FIG. 27 shows the two modules of FIG. 24 showing the split and loopback pathway for the module lacking the 2x2 switch;

FIG. 28 is a schematic diagram of a third embodiment of a fiber optic access module including a 2x2 loopback switch, and two 1x2 split switches, one positioned in each primary signal pathway;

FIG. 29 shows the module of FIG. 28 connected to fiber optic test equipment;

FIGS. 30–39 show various applications of the module of FIG. 29.

Detailed Description of the Preferred Embodiments

Referring now to FIG. 1A, a schematic representation of an optical circuit 1 in accordance with the present invention is shown including two optical signal pathways 2, 3 linking connection locations 4a and 4c, and 4b and 4d, respectively. Connection locations 4a–d may be any type of fiber optic connection system including fiber optic connectors/adapters, fiber optic splices, or other fiber optic connection system for transmitting fiber optic signals. A switch 5 between the two signal pathways 2, 3 allows normal passing through of the signals along each signal pathway in one state, and looping back of the signals in a second state. In the looping back state, connection location 4a can communicate with connection location 4b, and connection location 4c can communicate with connection location 4d. One example switch 5 is a 2x2 optical switch. Access to one or both of the signal pathways 2, 3 can be provided to the circuit by access arrangement 6, shown

in the example as providing access to signal pathway 3. Preferably, access arrangement 6 provides an optical link between signal pathway 3 and connection locations 4e and 4f. Access to signal pathway 3 can be provided by a variety of devices including non-intrusive monitors and/or switches, such as 1x2 switches or 2x2 switches. Access to other portions of signal pathway 3, such as between switch 5 and connection location 4d can also be provided instead of or in addition to access arrangement 6. Similarly, access arrangements can be provided in signal pathway 2, in a similar manner. Circuit 1 has a variety of applications in fiber optic systems where access to one or more of the fiber optic pathways is desired.

Referring now to FIG. 1, a first preferred embodiment of a fiber optic module 10 using the circuit features of FIG. 1A is shown for cross-connecting fiber optic cables, and for providing test and access locations. Module 10 includes an optical circuit 11 including a transmit signal pathway 12 and a receive signal pathway 14 extending between fiber optic terminals or ports 16 and cross-connect terminals or ports 18. Specifically, fiber optic terminals (FOT) 16 include a transmit terminal T1 and a receive terminal R1. Cross-connect terminals 18 include transmit terminal T2 and receive terminal R2. Preferably, module 10 includes access terminals or ports for allowing access to signals passing through module 10. For example, test equipment and/or monitors can be optically linked to one of the transmit or receive signal pathways 12, 14. In the embodiment of FIG. 1, test equipment 20, and monitor 22 is linked to transmit signal pathway 12.

While use of two modules cross-connected together is shown in FIGS. 1-27, it is to be appreciated that circuit 11 can be mounted in other module housings, racks or frames, and circuit 11 can be part of a larger circuit within the same module housing, rack or frame as desired.

One or more switches are provided to selectively connect and disconnect the various signal pathways within module 10. For example, a first switch 24 is positioned to selectively connect and disconnect transmit signal pathway 12 with receive signal pathway 14. Further, switch 24 disconnects the connection between terminals T1 and T2, and terminals R1 and R2, when transmit signal pathway 12 is linked to receive signal pathway 14. A 2x2 optical switch is one preferred structure for switch 24.

As shown in FIG. 1, a second 2x2 optical switch is provided between terminal T1 and first switch 24. Second switch 30 allows a normal through path along transmit signal pathway 12 between terminals T1 and T2. Switch 30 further provides a loopback pathway between pathways 26 and 28 so as to optically link receive terminal R3 with transmit terminal T3 of test equipment 20. When second switch 30 is placed in a second state, transmit signal pathway 12 is interrupted and

terminal T1 becomes optically linked with terminal R3, and terminal T3 becomes optically linked with terminal T2.

5 In module 10 of FIG. 1, a splitter 32 splits a portion of the signal from transmit signal pathway 12 and diverts it to a monitor pathway 34 optically linked to monitor terminal T1. Access to monitor pathway is by monitor terminal R4. One preferred splitter is a 90%–10% type splitter, although any percentage splitter is useable.

Module 10 can be utilized in five modes of operation if desired: normal, loopback, split/loopback, split, and monitor. In the normal mode of
10 operation, first and second switches 24, 30 will be positioned so that the signals flow from terminals T1 to T2, and from terminals R2 to R1. The normal mode of operation also provides a loopback of the test equipment through second switch 30. Monitor mode is present at all times to monitor the signal in transmit signal pathway 12.

15 When the first switch 24 is in the loopback position, and the second switch 30 is in the normal position, module 10 is in the loopback mode. The signals flow from terminals T1 to R1, from terminals T2 to R2, and from terminals T3 to R3.

20 When the first switch 24 is in the loopback position and the second switch 30 is in the split position, module 10 is in the split/loopback mode. The signals flow from terminals T1 to R3, from terminals T2 to R2 and from terminals T3 to R1.

25 When the second switch 30 is in the split position and the first switch 24 is in the normal position, module 10 is in the split mode. The signals flow from terminals T1 to R3, from terminals T3 to T2, and from terminals R2 to R1.

FIG. 2 illustrates schematically various features for module 10'. Module 10 of FIG. 1 is one embodiment of module 10'. Module 10' includes a 2x2 switch 32 in receive signal pathway 14. Typically, although not required, such a switch would be provided instead of second switch 30. Also, other monitors 22a,
30 22b, 22c may be provided at various points in the transmit and receive signal pathways 12, 14, if desired. Generally, module 10' would not likely exist with all of the features shown. FIG. 2 is provided to illustrate the wide variety of functions that could be provided as desired to access and monitor the various signal pathways at various points in the module. FIG. 3 shows schematically the module 10'
35 representation of FIG. 2 cross-connected at cross-connection location 40 to a second module 10".

Referring now to FIG. 4, the optical switches 24, 30 of module 10 can be operated remotely, if desired. Remote control is useful for remote accessing with

test equipment. Alternatively, switches could be operated manually. In the case of remote control, control logic 50 is provided for each module 10₁, 10₂...10_n. Links 52, 54 between control logic 50 operate each switch 24, 30. A network control/database 60 controls each control logic 50₁, 50₂...50_n by a link 58. Link 58 can be by ethernet, RS232, RS485, or other links. FIG. 4 also illustrates distributed control by controller 62 which may provide central local control of control logic 50 of each module 10 through links 63.

Referring now to FIGS. 5-9, a fiber optic chassis 70 is shown for holding a plurality of the fiber optic modules 10. Chassis 70 is mountable to a rack (not shown) for holding chassis 70. Chassis 70 includes an outer housing 72 and a pivotally mounted front door (not shown) hinged at hinge 74. Front door allows access to an interior of chassis 70, so as to access individual modules 10 such as for repair or replacement of modules 10 or to connect or disconnect the modules with other modules or fiber optic equipment. Chassis 70 includes a plurality of guides 76 for holding the individual modules 10 in a horizontal manner. Side opening 78 and cable clips 79 allows for cable pathways into and out of chassis 70.

Modules 10 have connection locations, terminals or ports 80 along the front and the rear. The modules 10 may be used for interconnecting the fiber optic equipment as desired, instead of through a traditional cross-connect connection.

Module 10 has a module housing 90 including a front face 92 and an opposite facing rear face 94. The front and rear faces 92, 94 each define connection locations 80 for connecting module 10 to fiber optic cables. In the embodiment shown, the front connection locations 80 are angled relative to front face 92, and the rear connection locations 80 extend transversely relative to rear face 94.

Module 10 further includes opposed major planar sides 96, 98. Module 10 further includes opposed minor planar sides 100, 102 defining sides of module 10 in the embodiment shown. Major side 96 has side extensions or flanges 104 which form slide rails for receipt in guides 76 of chassis 70. The module and chassis interface may be configured in accordance with commonly owned U.S. Patent No. 5,363,465, which permits the modules to be flipped as they are moved from the left side to the right side and vice versa. Module 10 can be mounted vertically, if desired, instead of horizontally in a suitably configured chassis.

Module 10 includes a plurality of first adapters 106a-e (generally 106) exposed along front face 92 for the front connection locations 80 for connection to fiber optic connectors 108. In the FIGS. only adapters 106a and 106e are shown, but adapters 106b-d are similarly constructed. Adapters 106 are mounted to front face 92 by angled retainers 93, such as the type described and shown in U.S. Patent

No. 5,214,735. A plurality of second adapters 110a,b (generally 110) are positioned along rear face 94 for the rear connection locations 80, also for connection to fiber optic connectors 112. The first and second adapters 106, 110 are preferably positioned in linear arrays parallel to front and rear faces 92, 94. The adapters
5 shown are SC type, but could also be FC, ST, or any other suitable connection scheme. Two of the first adapters 106 (106a,b) are used to cross-connect fiber optic equipment connected to the second adapters 110a,b of module 10. Alternatively, module 10 can be interconnected to other equipment via front adapters 106. In the illustrated embodiment, adapter 106c defines a monitor port, and adapters 106d,e are
10 used as access locations such as for connection to test equipment.

Module 10 includes two openings 111 which are not used in module 10. Now with reference to FIGS. 5 and 6, an additional module 200 is shown. Module 200 is a double density module where two pieces of equipment can be connected to module 200, for cross-connection through module 200 at front
15 adapters 106. Front adapters 106 are dual density adapters.

Module 10 further includes end flanges 114 for use in mounting module 10 to chassis 70. Locking members 116 releasably hold flanges 114 to chassis 70. Locking members 116 include spring loaded and retained screws. Other locking members, besides screws may be used as desired, such as the type shown
20 and described in U.S. Patent No. 5,363,465 which operate to lock or release by rotating 90°.

Modules 10, 200 are electrically powered and are connected to a controller module 202 through a controller bus 204 of chassis 70. Plug 95 connects each module 10 to bus 204.

25 Referring now to FIGS. 10-20, two modules 210, 212 are shown cross-connected to one another in a system 208. Modules 210, 212 may be in the same chassis, or different chassis. Also modules 210, 212 may be in different locations altogether.

Modules 210, 212 are each also connected to test equipment 214.
30 Test equipment 214 is shown as different test circuits which may not be part of the same test unit. Optical 1xN switches 250, 252 connect the test equipment 214 to modules 210, 212. Optical 1xN switches 254, 256 also connect monitor test equipment 214a, 214b to modules 210, 212. The various switches 250, 252, 254, 256 can be remotely operated. Modules 210, 212 differ from module 10 in that
35 instead of a 2x2 switch 30 connecting the test equipment from the transmit signal pathway, a 2x2 switch 216 connects the receive signal pathway to the test equipment. FIGS. 11-20 illustrate various applications of the two modules 210, 212.

FIG. 11 shows system 208 with modules 210, 212 operating in a normal or transparent mode in which the transmit signal of module 210 from transmit port 230 is received at receive port 240. Further a transmit signal from transmit port 236 is received at receive port 234 of module 210.

5 FIG. 12 illustrates system 208 in a transmit and receive loopback mode once switches 24 are switched from the normal positions to the loopback positions. FIG. 13 illustrates use of system 200 in a loopback mode for the test equipment by maintaining second switches 116 in the normal position.

10 FIG. 14 illustrates system 208 in a split and loopback mode in which switch 24 is positioned in the loopback position, and switch 216 of module 210 is positioned in the split position. FIG. 15 shows a similar arrangement with respect to second module 212. FIG. 16 shows both modules being operated in the split and loopback mode.

15 FIG. 17 shows system 208 being operated in a split mode where the transmit signal of module 212 is received by the test equipment of module 210. Further, the transmit signal from the test equipment is received by receive port 234 of module 210. FIG. 18 shows a transmit signal from transmit port 230 being received by the test equipment of module 212. The transmit signal of the test equipment of module 212 is received by receive port 240 of module 212. FIG. 19
20 shows both modules 210, 212 being operated in the split mode.

FIG. 20 shows both modules 210, 212 being operated in the monitor mode so as to monitor the output from both transmit ports 230, 236 of the respective test equipment.

25 Referring now to FIGS. 21-24, an alternative embodiment of a module 310 is shown similar to module 10 including a first 2x2 switch 24, but further including a 1x2 switch 320 instead of second switch 30. Module 310 also includes a splitter 332 and a monitor pathway 334 to monitor test equipment. The 1x2 switch 320 allows for module 310 to be manufactured more inexpensively since a 2x2 switch is avoided. However, no loopback to the test equipment is possible as
30 for module 10. Also, only a portion (in the example shown, 10%) of the signal can be tested from terminal T1.

While the preferred embodiments show the modules 210, 212 including the 2x2 switches 24, 30, it is to be appreciated that only one module in the circuit may be provided with the switching features.

35 FIG. 22 shows various features which may be utilized in the various possible configurations for module 310' including positioning of the 1x2 switch in the receive signal pathway. Also, various monitors are shown for monitoring other portions of the signal pathways. FIG. 23 shows schematically two modules cross-

connected 310', 310", and including all of the various options available for the two modules.

Referring now to FIG. 24, two modules 310 are shown cross-connected to one another in a system 308. Modules 310 may be in the same chassis or different chassis. Also, modules 310 may be in different locations altogether.

Modules 310 are each also connected to test equipment 314. Test equipment 314 is shown as different test circuits which may not be part of the same test unit. As above in system 208, optical 1xN switches 350, 352 connect the test equipment 314 to modules 310. The switches 350, 352 can be remotely operated. System 308 can be operated under various applications depending on the positioning of switches 24, 320.

Referring now to FIGS. 25-27, two modules 310, 310a are shown cross-connected to one another in a system 308a. Module 310a is the same as module 310, except module 310a lacks a 2x2 switch 24. Cost savings may be realized for module 310a due to its simpler design with less parts. FIGS. 26 and 27 show the loopback mode of operation (FIG. 26) and the split and loopback mode of operation (FIG. 27) whereby switch 24 of module 310 is operated in order to achieve the loopback relative to module 310a.

Referring now to FIGS. 28-39, a further preferred embodiment of a module 410 is shown. Module 410 includes a single 2x2 switch 24 positioned between first and second signal pathways 412, 414. Signal pathways 412, 414 link a first pair of fiber optic terminals 416 with a second pair of terminals 418. Module 410 further includes a 1x2 switch 420 in each signal pathway 412, 414. Further, module 410 also includes a splitter 432 and a monitor pathway 434 linked to monitor test equipment in each signal pathway 412, 414. The 1x2 switches 420 allow for module 410 to be manufactured more inexpensively since only three switches 24, 420, 420 are provided. Module 410 is related to earlier described modules 10, 210, 212, 310, 310', 310", 310a. However, module 410 would be used instead of two of the above-noted modules which are described as being cross-connected together.

FIG. 29 shows module 410 connected to test equipment 414 and switches 450, 452 in a system 408, in a similar manner as noted above in systems 208, 308. FIGS. 30-39 show various applications of system 408 including module 410. FIG. 30 shows system 408 in the transparent mode for connection locations 460-463. FIG. 31 shows system 408 in a loopback mode for connection locations 460-463. FIG. 32 shows system 408 where the test equipment 414 is utilized in a loopback mode. A loopback circuit is provided in connection with one of the pairs of ports of each 1xN switch 450, 452. FIG. 33 shows a split and loopback mode for system 408 with respect to connection locations 460 and 461. FIG. 34 shows system

408 in a split and loop back mode with respect to connection locations 462 and 463. FIG. 35 shows system 408 where both pairs of connection locations 460 and 461, and 462 and 463 are in the split and loopback mode. FIG. 36 shows system 408 in a split mode for connection locations 460 and 461. FIG. 37 shows system 408 in a split mode with respect to connection locations 462 and 463. FIG. 38 shows system 408 where both pairs of connection locations are in a split mode. FIG. 39 shows system 408 in a monitor mode.

FIG. 29 is illustrative of a system 408 in which separate individual modules of the types described previously are not provided. Instead, the optical circuitry of system 408 may be provided in a single module 410. It is to be appreciated that the various optical circuits described above for connecting telecommunications equipment, cables, and monitor, test, and access equipment may be provided in a number of physical constructions, including the preferred modular constructions noted above. In addition, the circuitry can be provided on differently configured modules, an increased or decreased number of modules, or as part of other frames, racks, or housings associated with telecommunications and data connectivity systems. Similarly, the cross-connections noted above for individual modules, such as module 10, can be by patch cords including connectors matable with adapters of module 10, or the connections can be by other optical links which may or may not include patch cords. For example, an optical link may be provided through controller bus 204 of chassis 70 shown in FIGS. 5 and 6.

The above specification and examples provide a complete description of the manufacture and use of the invention. Since many embodiments of the invention can be made without departing from the spirit and scope of the invention, the invention resides in the claims hereinafter appended.

What Is Claimed Is:

1. A fiber optic circuit comprising:
 - a) a plurality of connection locations, wherein the plurality of connection locations define first and second pairs of connection locations, each pair defining first and second connection points;
 - b) a first optical signal pathway between the first connection points;
 - c) a second optical signal pathway between the second connection points;
 - d) a first switch between the first and second optical signal pathways wherein the switch has first and second states:
 - 1) the first state being a normal through state wherein the first connection points are optically linked along the first optical signal pathway, and wherein the second connection points are optically linked along the second optical signal pathway; and
 - 2) the second state being a loopback state wherein the first and second connection points of the first pair are in communication along a first loopback path along a portion of the first and second optical signal pathways, and wherein the first and second connection points of the second pair are in communication along a second loopback path along other portions of the first and second optical signal pathways.
2. The circuit of claim 1, wherein the plurality of connection locations define a third pair of connection locations optically linkable with one of the first and second optical signal pathways.
3. The circuit of claim 2, further comprising a second switch located in the first optical signal pathway between the first connection point of the first pair and the first switch, the second switch having two states:
 - a) a first state being a normal state wherein the first connection point of the first pair is optically linked with the first switch, and wherein the third pair of connection locations optically communicate with one another along a loopback pathway; and
 - b) a second state being a split state wherein the one of the connection locations of the third pair is optically linked with the first connection point of the first pair, and wherein the other connection location of the third pair is optically linked with the first switch.
4. The circuit of claim 3, further comprising a fourth pair of connection locations optically linkable with the second optical signal pathway, and a third

switch located in the second optical signal pathway between the second connection point of the second pair and the first switch, the second switch having two states:

5 a) a first state being a normal state wherein the second connection point of the second pair is optically linked with the first switch, and wherein the fourth pair of connection locations optically communicate with one another along a loopback pathway; and

10 b) a second state being a split state wherein the one of the connection locations of the fourth pair is optically linked with the second connection point of the second pair, and wherein the other connection location of the fourth pair is optically linked with the first switch.

15 5. The circuit of claim 3, further comprising a splitter in the second optical signal pathway between the first switch and the second connection point of the first pair, and a monitor connection location optically linked with the splitter.

6. The circuit of claim 3, further comprising a splitter in the first optical signal pathway between the second switch and the first connection point of the first pair, and a monitor connection location optically linked with the splitter.

20 7. The circuit of claim 1, further comprising:

a) a module housing having front and rear faces, opposed major sides, and opposed minor sides defining an enclosed interior, the front face including mounting flanges for mounting the module to a chassis;

25 b) a plurality of exposed adapters defining the connection locations along at least one of the front and rear faces, each of the plurality of adapters connectable to a fiber optic connector external to the module.

30 8. The circuit of claim 7, wherein the module housing and the plurality of exposed adapters defines a first cross-connect module, further comprising a plurality of the first cross-connect modules, and a plurality of second cross-connect modules constructed and arranged as the first cross-connect module, the first and second cross-connect modules cross-connected together, and further comprising a plurality of first and second test circuits, each test circuit including transmit and receive signal connection locations, first and second dual 1xN optical switches, where N equals the
35 number of the plurality of first and second modules cross-connected together, the first and second dual 1xN optical switches optically linked to the third signal connection locations of the plurality of first and second modules, and test equipment optically linked to the first and second dual 1xN optical switches.

9. The circuit of claim 1, wherein the plurality of connection locations define a third connection location optically linkable with one of the first and second optical signal pathways.
- 5 10. The circuit of claim 9, further comprising a second switch located in the first optical signal pathway between the first connection point of the first pair and the first switch, the second switch having two states:
- 10 a) a first state being a normal state wherein the first connection point of the first pair is optically linked with the first switch, and wherein the third connection location is optically isolated; and
- b) a second state being a split state wherein the third connection location is optically linked with the first switch.
- 15 11. The circuit of claim 9, further comprising a second switch located in the second optical signal pathway between the first connection point of the first pair and the first switch, the second switch having two states:
- a) a first state being a normal state wherein the first connection point of the first pair is optically linked with the first switch, and wherein the third connection location is optically isolated; and
- 20 b) a second state being a split state wherein the third connection location is optically linked with the first switch.
12. The circuit of claim 10, further comprising a splitter in the first optical signal pathway between the second switch and the first connection point of the first pair, and a monitor connection location optically linked with the splitter.
- 25 13. The circuit of claim 11, further comprising a splitter in the second optical signal pathway between the first and second switches, and a monitor connection location optically linked with the splitter.
- 30 14. The circuit of claim 1, further comprising:
- a) a module housing having front and rear faces, opposed major sides, and opposed minor sides defining an enclosed interior, the front face including mounting flanges for mounting the module to a chassis;
- 35 b) a plurality of exposed adapters defining the connection locations along at least one of the front and rear faces, each of the plurality of adapters connectable to a fiber optic connector external to the module.

15. The circuit of claim 14, wherein the module housing and the plurality of exposed adapters defines a first cross-connect module, further comprising a plurality of the first cross-connect modules, and a plurality of second cross-connect modules constructed and arranged as the first cross-connect module, the first and second
5 modules cross-connected together, and further comprising a plurality of first and second test circuits, each test circuit including a main signal connection location and a monitor signal connection location, first and second dual 1xN optical switches, where N equals the number of plurality of first and second modules cross-connected together, the first and second dual 1xN optical switches optically linked to the main
10 signal connection locations and the monitor signal connection locations of the plurality of first and second modules, and test equipment optically linked to the first and second dual 1xN optical switches.

16. A fiber optic circuit comprising:
15 a) a plurality of accessible optical circuits each including:
1) a plurality of connection locations defining first and second transmit signal connection locations and first and second receive signal connection locations;
2) a transmit signal pathway between the first and second transmit
20 signal connection locations;
3) a receive signal pathway between the first and second receive signal connection locations;
4) a first switch between the transmit and receive signal pathways wherein the switch has first and second states:
25 A) the first state being a normal through state wherein the first and second transmit signal connection locations are optically linked along the transmit signal pathway, and wherein the first and second receive signal connection locations are optically linked along the receive signal pathway; and
B) the second state being a loopback state wherein the first
30 transmit signal connection location and the first receive signal connection location are in communication along a first loopback path along a portion of the transmit and receive signal pathways, and wherein the second transmit signal connection location and the second receive signal connection location are in communication along a second loopback path along other portions of the transmit and receive signal
35 pathways;
5) wherein the plurality of connection locations define a third signal connection location optically linkable through a second switch with one of the transmit and receive signal pathways;

6) a remote controller for controlling operation of the first and second switches;

b) optical links between the second transmit and receive signal connection locations of pairs of accessible circuits;

5 c) a central controller and a network connecting the remote controllers.

17. The system of claim 16, wherein the second switch is located in the transmit signal pathway between the first transmit signal connection location and the first switch, the second switch having two states:

10 a) a first state being a normal state wherein the first transmit signal connection location is optically linked with the first switch, and wherein the third signal connection location is optically isolated; and

b) a second state being a split state wherein the third receive signal connection location is optically linked with the first transmit signal connection location, and wherein the third transmit signal connection location is optically linked with the first switch.

18. The system of claim 16, wherein the second switch is located in the receive signal pathway between the first receive signal connection location and the first switch, the second switch having two states:

20 a) a first state being a normal state wherein the first receive signal connection location is optically linked with the first switch, and wherein the third signal connection location is optically isolated; and

b) a second state being a split state wherein the third transmit signal connection location is optically linked with the first receive signal connection location, and wherein the third receive signal connection location is optically linked with the first switch.

19. The system of claim 17, further comprising a splitter in the transmit signal pathway, and a monitor connection location optically linked with the splitter.

20. The system of claim 18, further comprising a splitter in the receive signal pathway, and a monitor connection location optically linked with the splitter.

35 21. A fiber optic circuit comprising:

a) first and second pairs of connection locations, each pair defining first and second connection points;

b) a first optical signal pathway between the first connection points;

c) a second optical signal pathway between the second connection points;

d) a first switch between the first and second optical signal pathways

wherein the first switch has first and second states:

1) the first state being a normal through state wherein the first
5 connection points are optically linked along the first optical signal pathway, and
wherein the second connection points are optically linked along the second optical
signal pathway; and

2) the second state being a loopback state wherein the first and
second connection points of the first pair are in communication along a first
10 loopback path along a portion of the first and second optical signal pathways, and
wherein the first and second connection points of the second pair are in
communication along a second loopback path along other portions of the first and
second optical pathways;

e) a second switch in the first optical signal pathway, and a third connection
15 point optically linkable through the second switch with the first optical signal
pathway, wherein the second switch is located between the first connection point of
the first pair and the first switch, the second switch having two states:

1) a first state being a normal state wherein the first connection point
of the first pair is optically linked with the first switch, and wherein the third
20 connection point is optically isolated from the first optical signal pathway; and

2) a second state being a split state wherein the third connection
point is optically linked with the first switch, and wherein the first connection point
of the first pair is optically isolated from the first switch;

f) a third switch in the second optical signal pathway, and a fourth
25 connection point optically linkable through the third switch with the second optical
signal pathway, wherein the third switch is located between the second connection
point of the second pair and the first switch, the third switch having two states:

1) a first state being a normal state wherein the second connection
point of the second pair is optically linked with the first switch, and wherein the
30 fourth connection point is optically isolated from the second optical signal pathway;
and

2) a second state being a split state wherein the fourth connection
point is optically linked with the first switch, and wherein the second connection
point of the second pair is optically isolated from the first switch.

35

22. The circuit of claim 21, further comprising a splitter in the first optical signal
pathway, and a monitor connection point optically linked with the splitter.

23. The circuit of claim 21, further comprising a splitter in the second optical signal pathway, and a monitor connection point optically linked with the splitter.
24. The circuit of claim 21, wherein the third and fourth switches are 2x2 switches.
25. The circuit of claim 21, wherein the third and fourth switches are 1x2 switches.
- 10 26. A fiber optic cross-connect module mountable to a chassis comprising:
- a) a module housing having front and rear faces, opposed major sides, and opposed minor sides defining an enclosed interior, the front face including mounting flanges for mounting the module to the chassis;
 - b) a plurality of exposed adapters along at least one of the front and rear
 - 15 faces, each of the plurality of adapters connectable to a fiber optic connector external to the module; wherein the plurality of adapters define first and second transmit signal ports and first and second receive signal ports;
 - c) a transmit signal pathway between the first and second transmit signal ports;
 - 20 d) a receive signal pathway between the first and second receive signal ports;
 - e) a first switch between the transmit and receive signal pathways wherein the switch has first and second states:
 - 1) the first state being a normal through state wherein the first and second transmit signal ports are optically linked along the transmit signal pathway,
 - 25 and wherein the first and second receive signal ports are optically linked along the receive signal pathway; and
 - 2) the second state being a loopback state wherein the first transmit signal port and the first receive signal port are in communication along a first loopback path along a portion of the transmit and receive signal pathways, and
 - 30 wherein the second transmit signal port and the second receive signal port are in communication along a second loopback path along other portions of the transmit and receive signal pathways.
27. The module of claim 26, wherein the plurality of exposed adapters define
- 35 third transmit and receive signal ports optically linkable with one of the transmit and receive signal pathways.

28. The module of claim 27, further comprising a second switch located in the transmit signal pathway between the first transmit signal port and the first switch, the second switch having two states:

- 5 a) a first state being a normal state wherein the first transmit signal port is optically linked with the first switch, and wherein the third transmit and receive signal ports optically communicate with one another along a loopback pathway; and
- b) a second state being a split state wherein the third receive signal port is optically linked with the first transmit signal port, and wherein the third transmit signal port is optically linked with the first switch.

10

29. The module of claim 27, further comprising a second switch located in the receive signal pathway between the first receive signal port and the first switch, the second switch having two states:

- 15 a) a first state being a normal state wherein the first receive signal port is optically linked with the first switch, and wherein the third transmit and receive signal ports optically communicate with one another along a loopback pathway; and
- b) a second state being a split state wherein the third transmit signal port is optically linked with the first receive signal port, and wherein the third receive signal port is optically linked with the first switch.

20

30. The module of claim 28, further comprising a splitter in the transmit signal pathway, and a monitor port optically linked with the splitter.

31. The module of claim 29, further comprising a splitter in the receive signal pathway, and a monitor port optically linked with the splitter.

25

32. The module of claim 28, wherein the module is a first module, further comprising a plurality of the first modules, and a plurality of second modules constructed and arranged as the first module, the first and second modules cross-connected together, and further comprising a plurality of first and second test circuits, each test circuit including transmit and receive signal ports, first and second dual 1xN optical switches, where N equals the number of the plurality of first and second modules cross-connected together, the first and second dual 1xN optical switches optically linked to the third transmit and receive signal ports of the plurality of first and second modules, and test equipment optically linked to the first and second dual 1xN optical switches.

30
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33. The module of claim 29, wherein the module is a first module, further comprising a plurality of the first modules, and a plurality of second modules constructed and arranged as the first module, the first and second modules cross-connected together, and further comprising a plurality of first and second test
5 circuits, each test circuit including transmit and receive signal ports, first and second dual 1xN optical switches, where N equals the number of the plurality of first and second modules cross-connected together, the first and second dual 1xN optical switches optically linked to the third transmit and receive signal ports of the plurality of first and second modules, and test equipment optically linked to the first and
10 second dual 1xN optical switches.

34. The module of claim 26, wherein the plurality of exposed adapters define a third signal port optically linkable with one of the transmit and receive signal pathways.
15

35. The module of claim 34, further comprising a second switch located in the transmit signal pathway between the first transmit signal port and the first switch, the second switch having two states:

a) a first state being a normal state wherein the first transmit signal port is
20 optically linked with the first switch, and wherein the third signal port is optically isolated; and

b) a second state being a split state wherein the third signal port is optically linked with the first switch.

36. The module of claim 34, further comprising a second switch located in the receive signal pathway between the first receive signal port and the first switch, the second switch having two states:

a) a first state being a normal state wherein the first receive signal port is optically linked with the first switch, and wherein the third signal port is optically
30 isolated; and

b) a second state being a split state wherein the third signal port is optically linked with the first switch.

37. The module of claim 35, further comprising a splitter in the transmit signal
35 pathway, and a monitor port optically linked with the splitter.

38. The module of claim 36, further comprising a splitter in the receive signal pathway, and a monitor port optically linked with the splitter.

39. The module of claim 37, wherein the module is a first module, further comprising a plurality of the first modules, and a plurality of second modules constructed and arranged as the first module, the first and second modules cross-connected together, and further comprising a plurality of first and second test
5 circuits, each test circuit including a main signal port and a monitor signal port, first and second dual 1xN optical switches, where N equals the number of the plurality of first and second modules cross-connected together, the first and second dual 1xN optical switches optically linked to the main signal ports and monitor signal ports of the plurality of first and second modules, and test equipment optically linked to the
10 first and second dual 1xN optical switches.

40. The module of claim 38, wherein the module is a first module, further comprising a plurality of the first modules, and a plurality of second modules constructed and arranged as the first module, the first and second modules cross-
15 connected together, and further comprising a plurality of first and second test circuits, each test circuit including a main signal port and a monitor signal port, first and second dual 1xN optical switches, where N equals the number of plurality of first and second modules cross-connected together, the first and second dual 1xN optical switches optically linked to the main signal ports and the monitor signal ports
20 of the plurality of first and second modules, and test equipment optically linked to the first and second dual 1xN optical switches.

41. A fiber optic cross-connect system comprising:
a) a plurality of modules including:
25 1) a plurality of connection locations connectable to a fiber optic connector external to the module; wherein the plurality of connection locations define first and second transmit signal ports and first and second receive signal ports;
2) a transmit signal pathway between the first and second transmit signal ports;
30 3) a receive signal pathway between the first and second receive signal ports;
4) a first switch between the transmit and receive signal pathways wherein the switch has first and second states:
A) the first state being a normal through state wherein the
35 first and second transmit signal ports are optically linked along the transmit signal pathway, and wherein the first and second receive signal ports are optically linked along the receive signal pathway; and

B) the second state being a loopback state wherein the first transmit signal port and the first receive signal port are in communication along a first loopback path along a portion of the transmit and receive signal pathways, and wherein the second transmit signal port and the second receive signal port are in communication along a second loopback path along other portions of the transmit and receive signal pathways;

5 5) wherein the plurality of connection locations define third transmit and receive signal ports optically linkable through a second switch with one of the transmit and receive signal pathways;

10 6) a remote controller for controlling operation of the first and second switches;

 b) optical cross connections between the second transmit and receive signal ports of pairs of modules;

 c) a central controller and a network connecting the remote controllers.

15 42. The system of claim 41, wherein the second switch is located in the transmit signal pathway between the first transmit signal port and the first switch, the second switch having two states:

 a) a first state being a normal state wherein the first transmit signal port is optically linked with the first switch, and wherein the third transmit and receive signal ports optically communicate with one another; and

20 b) a second state being a split state wherein the third receive signal port is optically linked with the first transmit signal port, and wherein the third transmit signal port is optically linked with the first switch.

25 43. The system of claim 41, wherein the second switch is located in the receive signal pathway between the first receive signal port and the first switch, the second switch having two states:

 a) a first state being a normal state wherein the first receive signal port is optically linked with the first switch, and wherein the third transmit and receive signal ports optically communicate with one another; and

30 b) a second state being a split state wherein the third transmit signal port is optically linked with the first receive signal port, and wherein the third receive signal port is optically linked with the first switch.

35 44. The system of claim 42, further comprising a splitter in the transmit signal pathway, and a monitor port optically linked with the splitter.

45. The system of claim 43, further comprising a splitter in the receive signal pathway, and a monitor port optically linked with the splitter.
46. A fiber optic circuit comprising:
- 5 a first optical signal pathway between first and second connection points;
a second optical signal pathway between third and fourth connection points;
means for selectively isolating the first and second connection points and the
third and fourth connection points, and further linking the first and second optical
signal pathways so as to provide a loop back between the first and third connection
10 points, and between the second and fourth connection points;
means for providing access to the first optical signal pathway to optically link
fifth and sixth connection points to the first optical signal pathway.
47. The fiber optic circuit of claim 46, further comprising means for providing
15 access to the second optical signal pathway to optically link seventh and eighth
connection points to the second optical signal pathway.

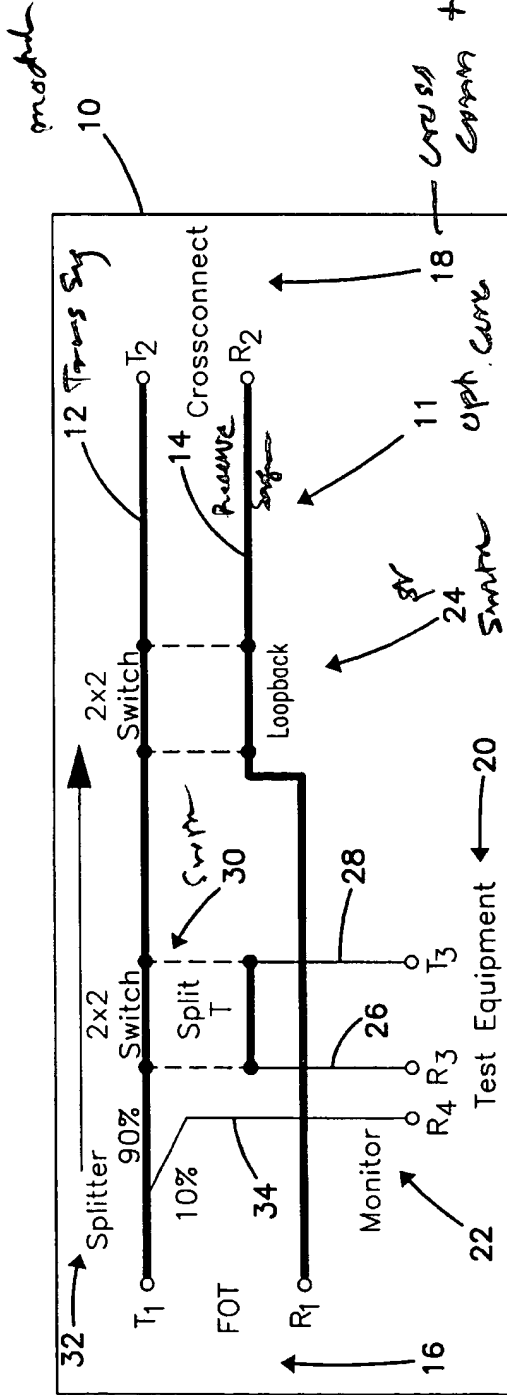


FIG. 1

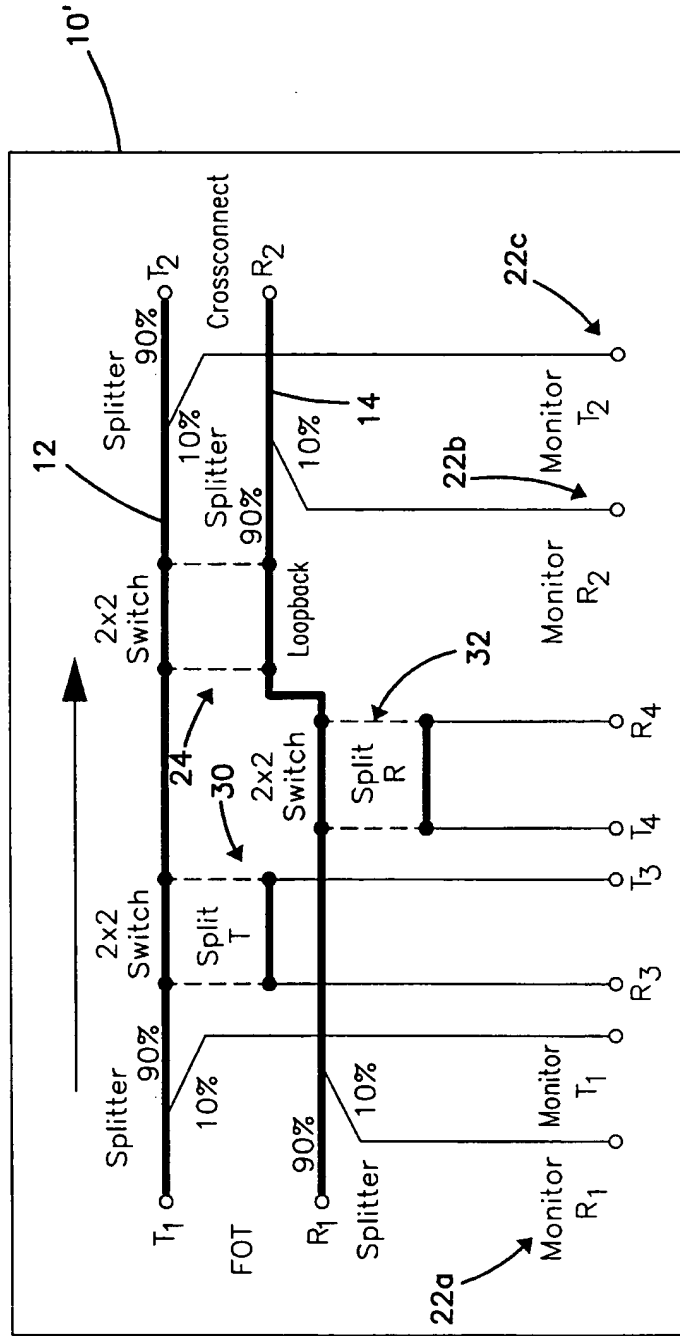


FIG. 2

FIG. 1A

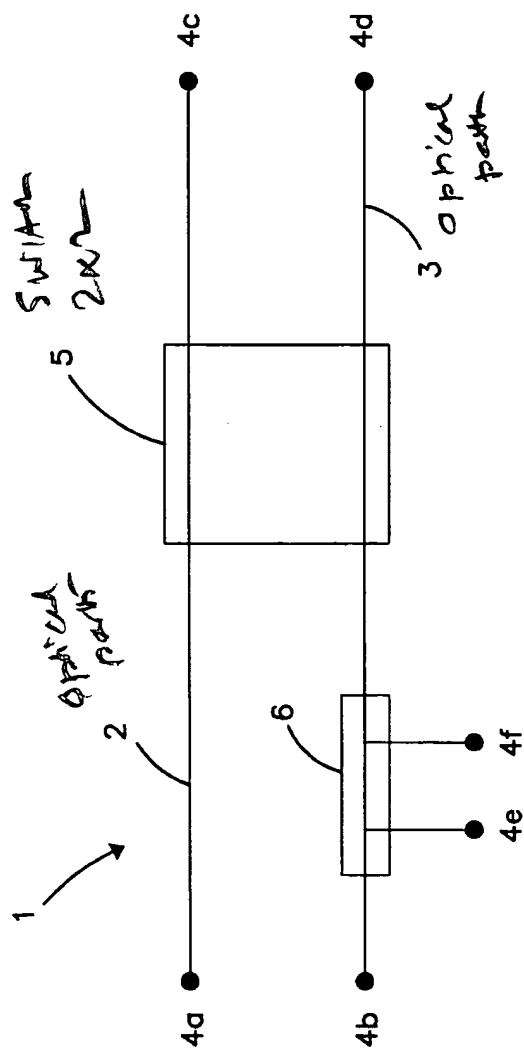


FIG. 3

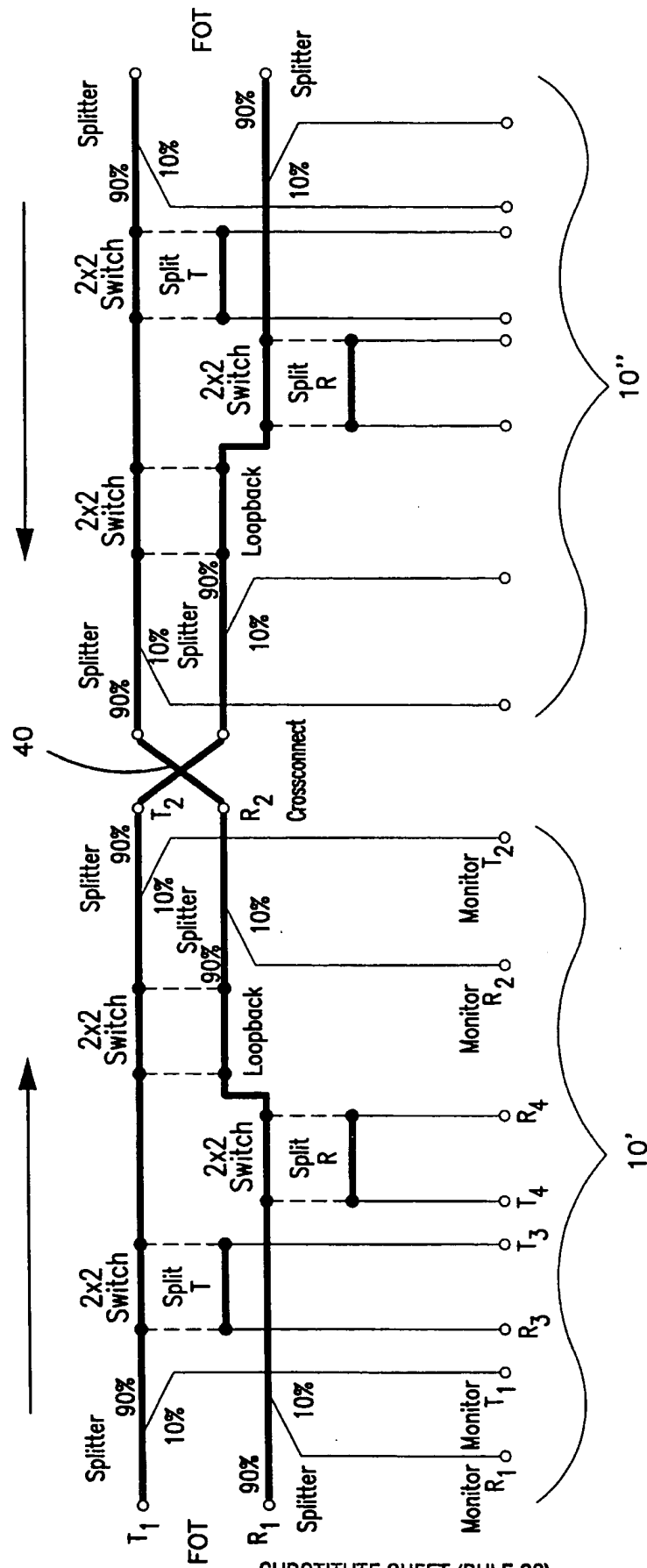
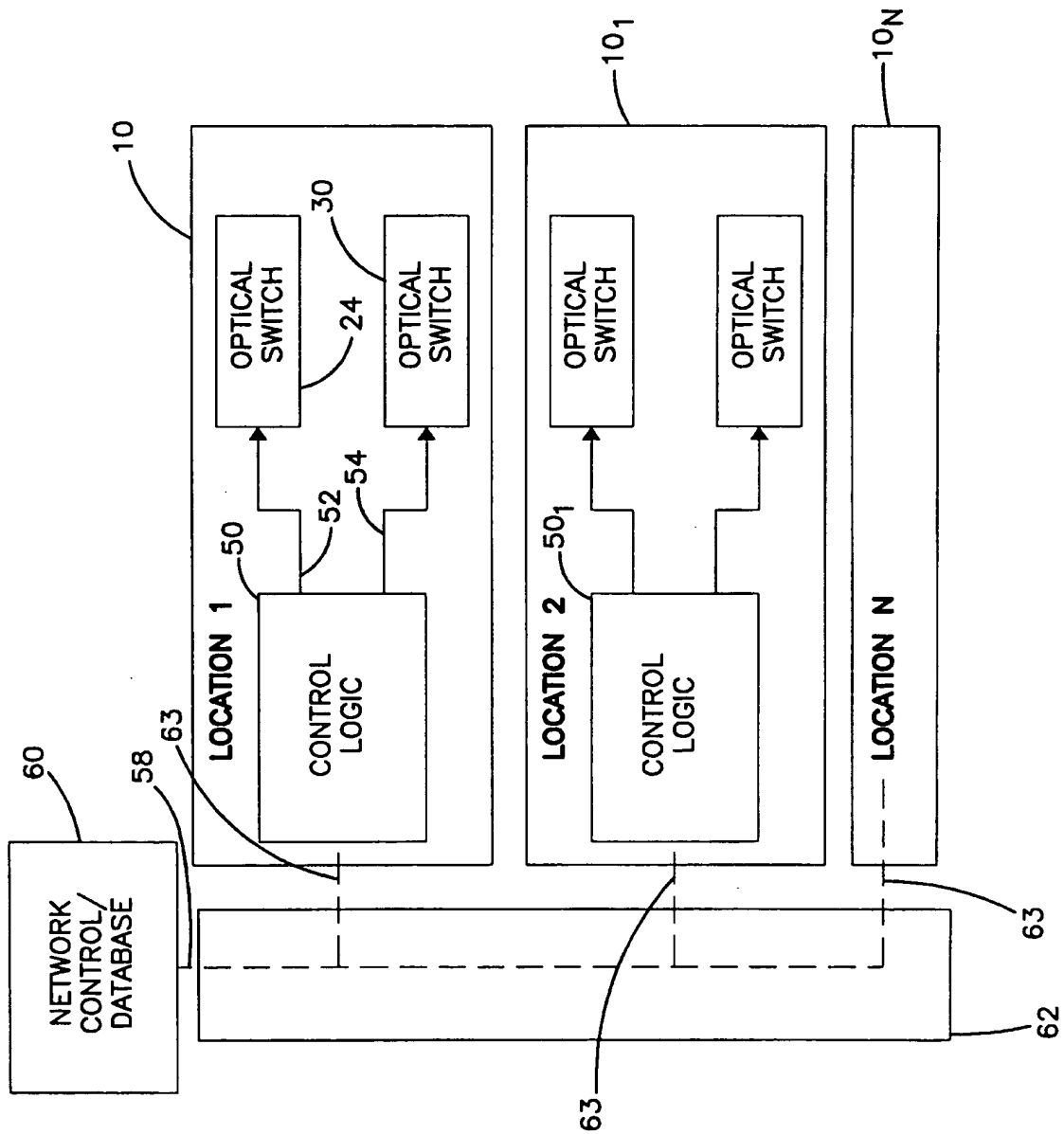


FIG. 4



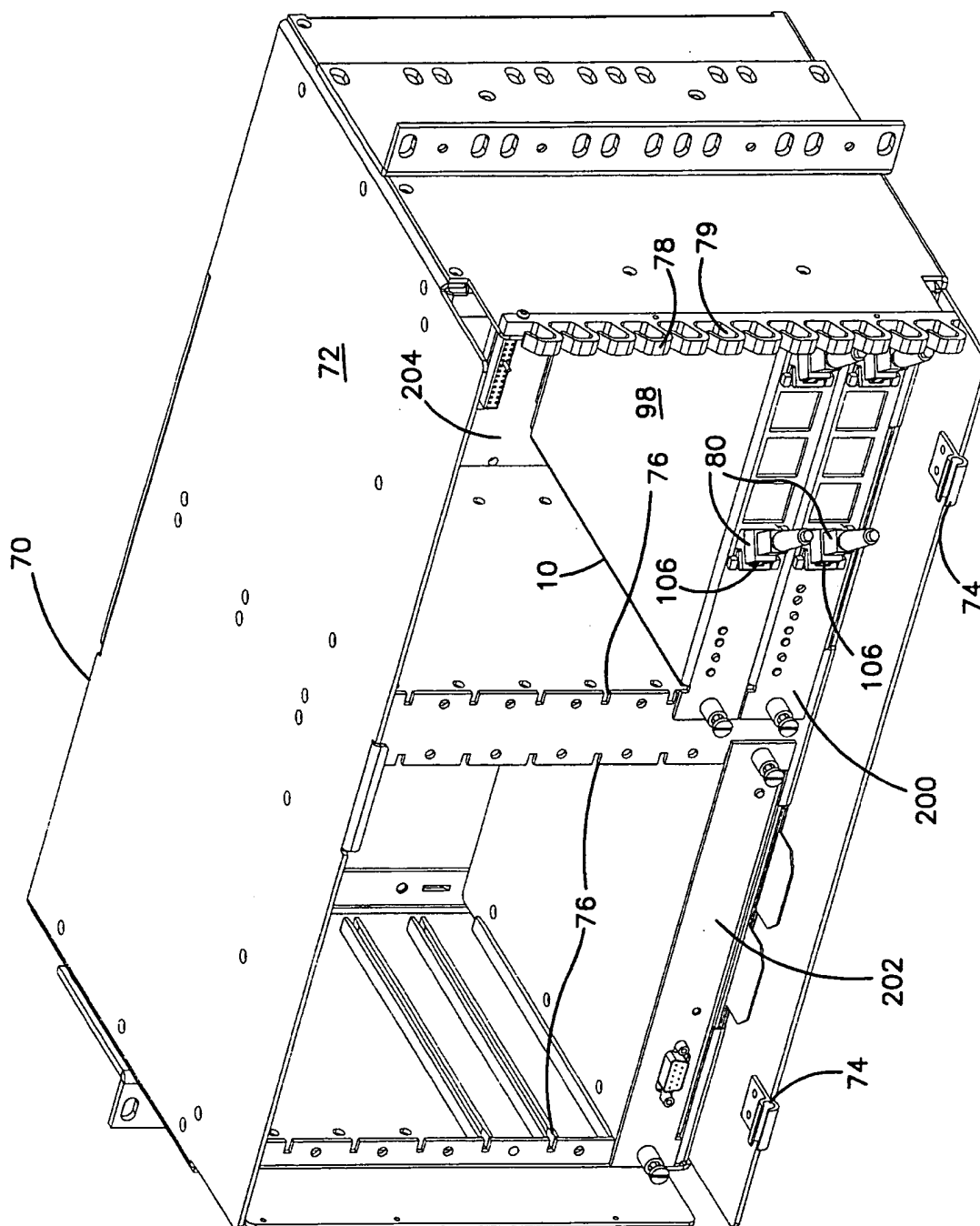
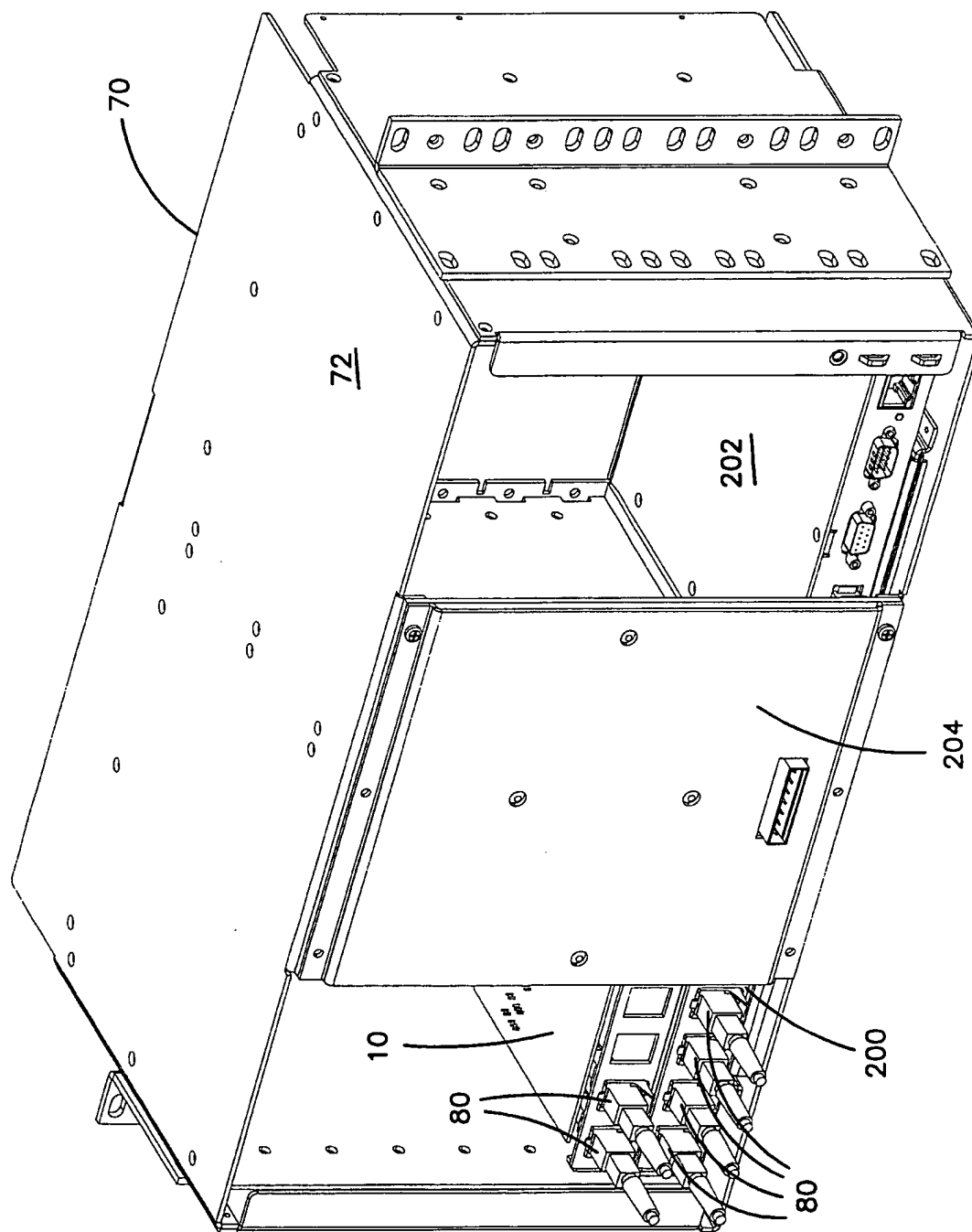


FIG. 5

FIG. 6



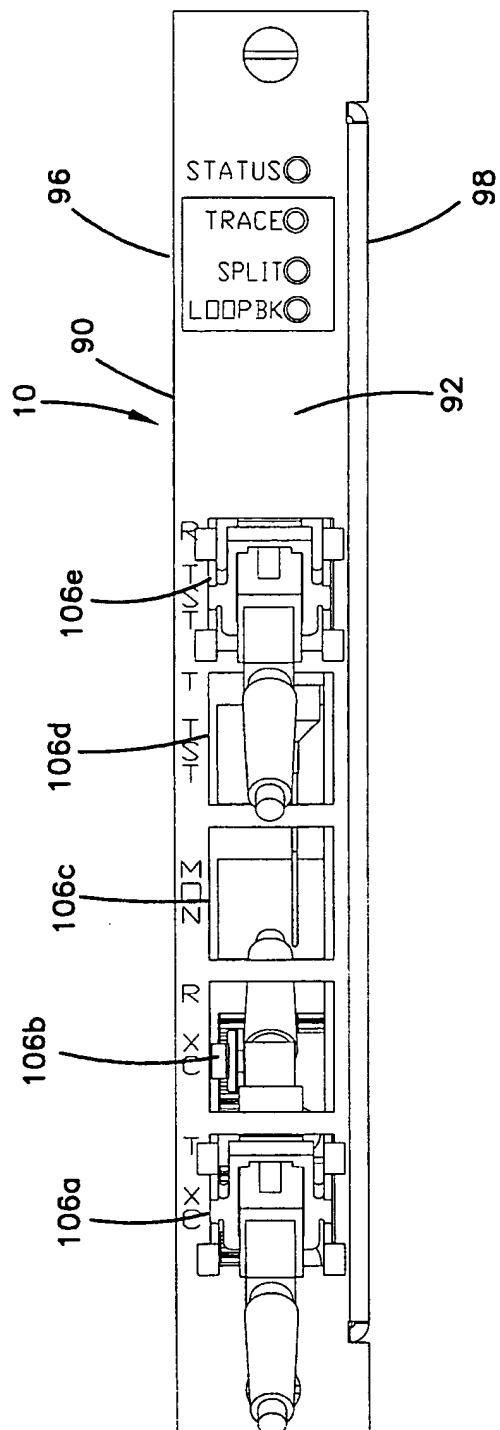


FIG. 7

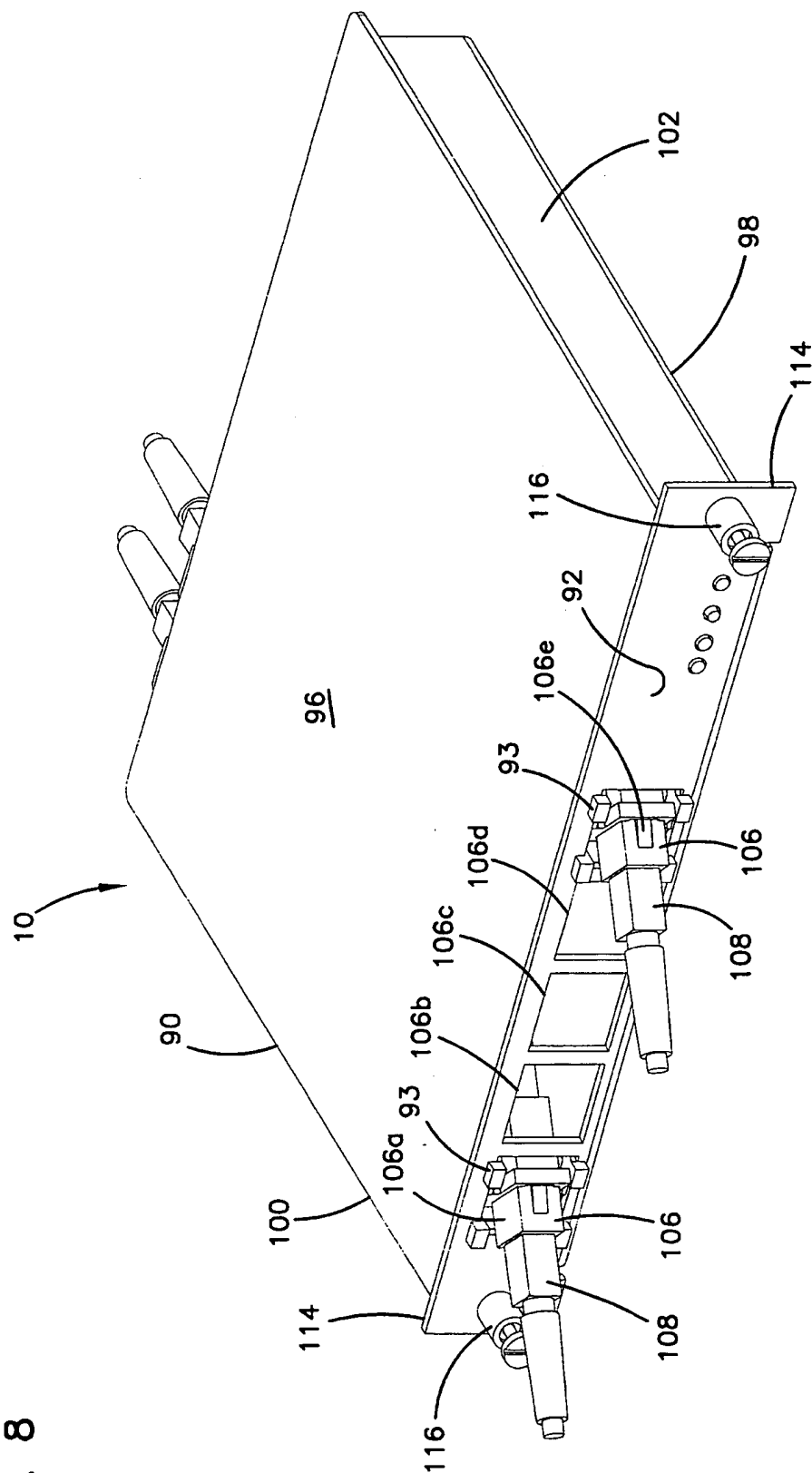
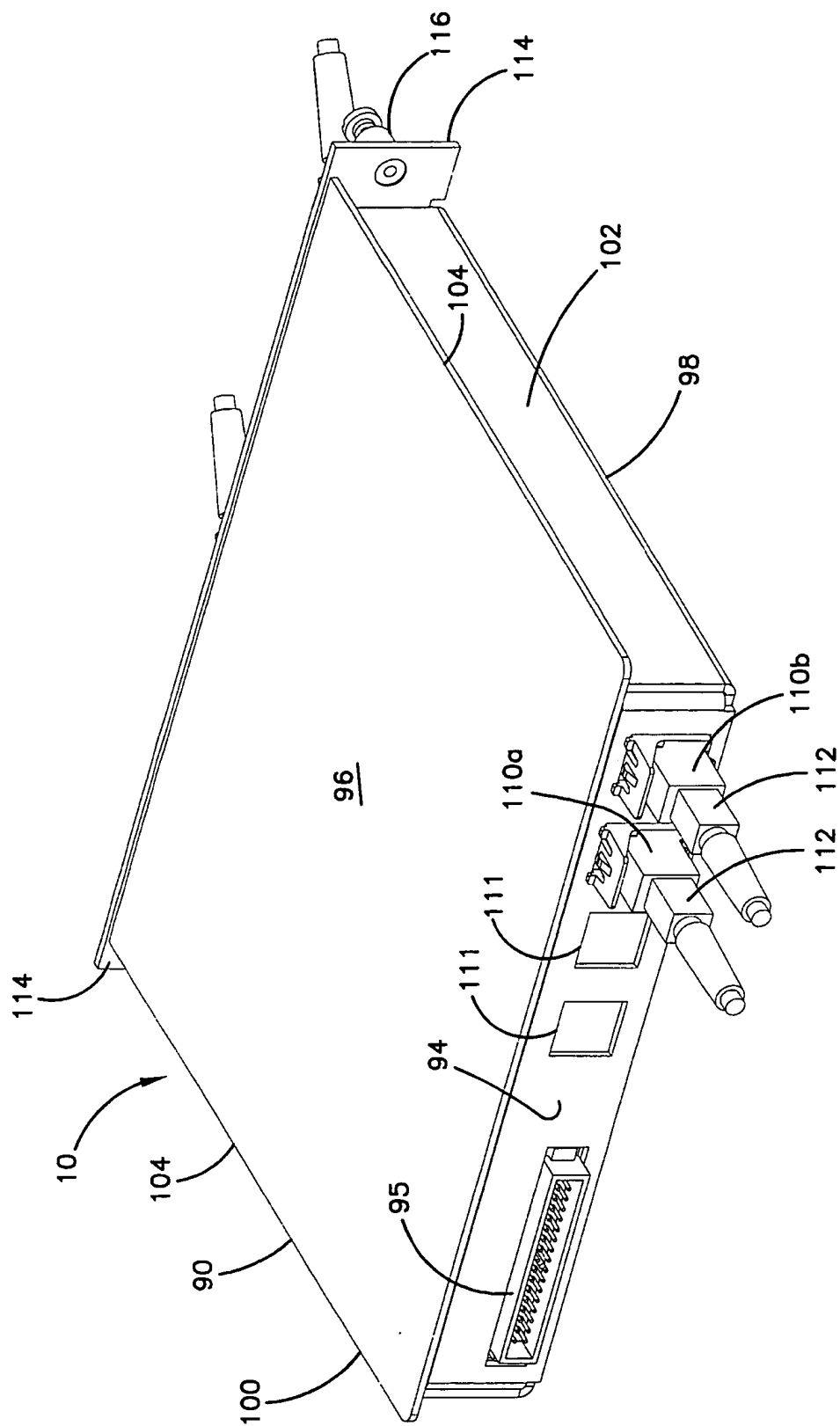
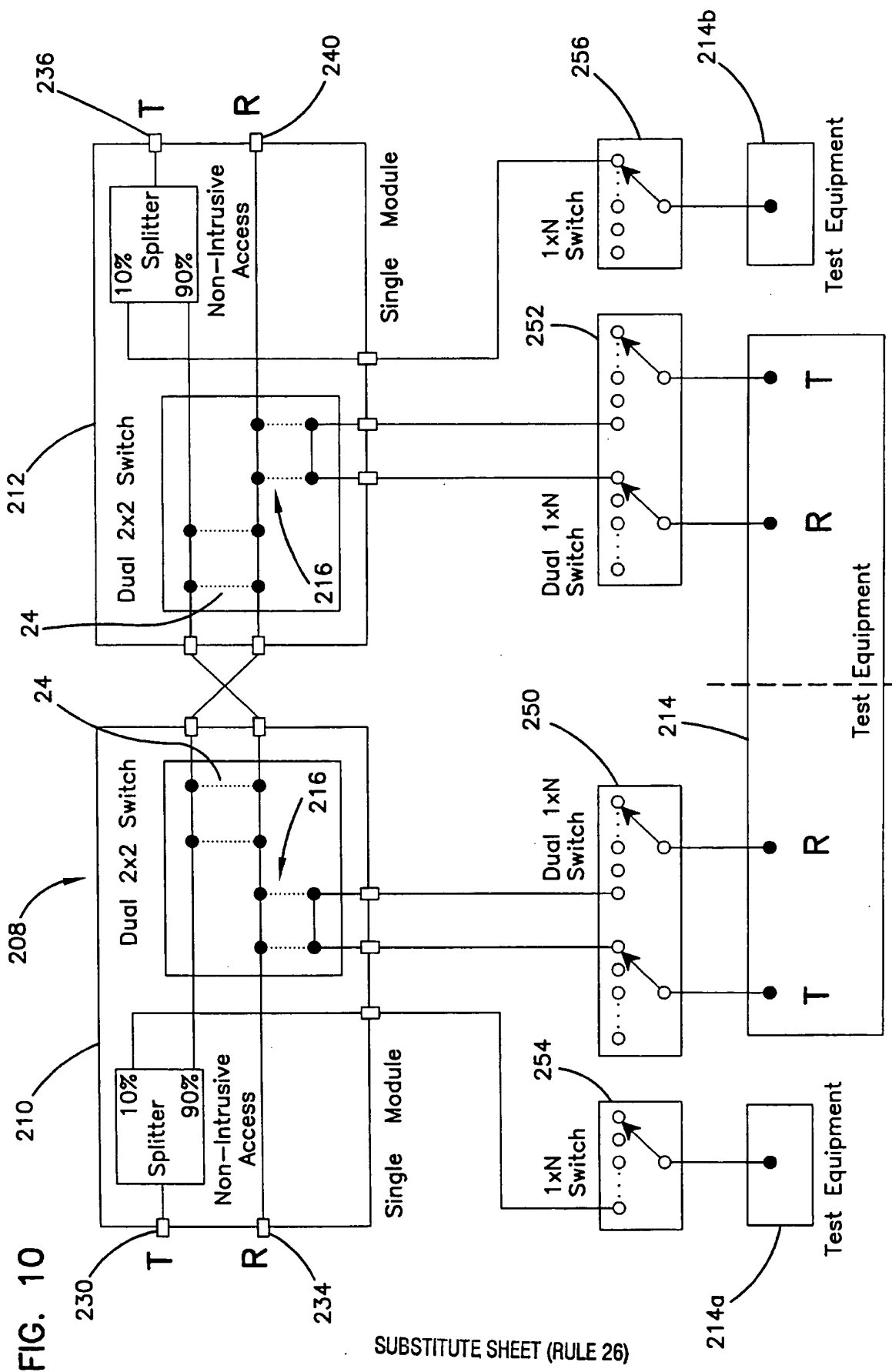


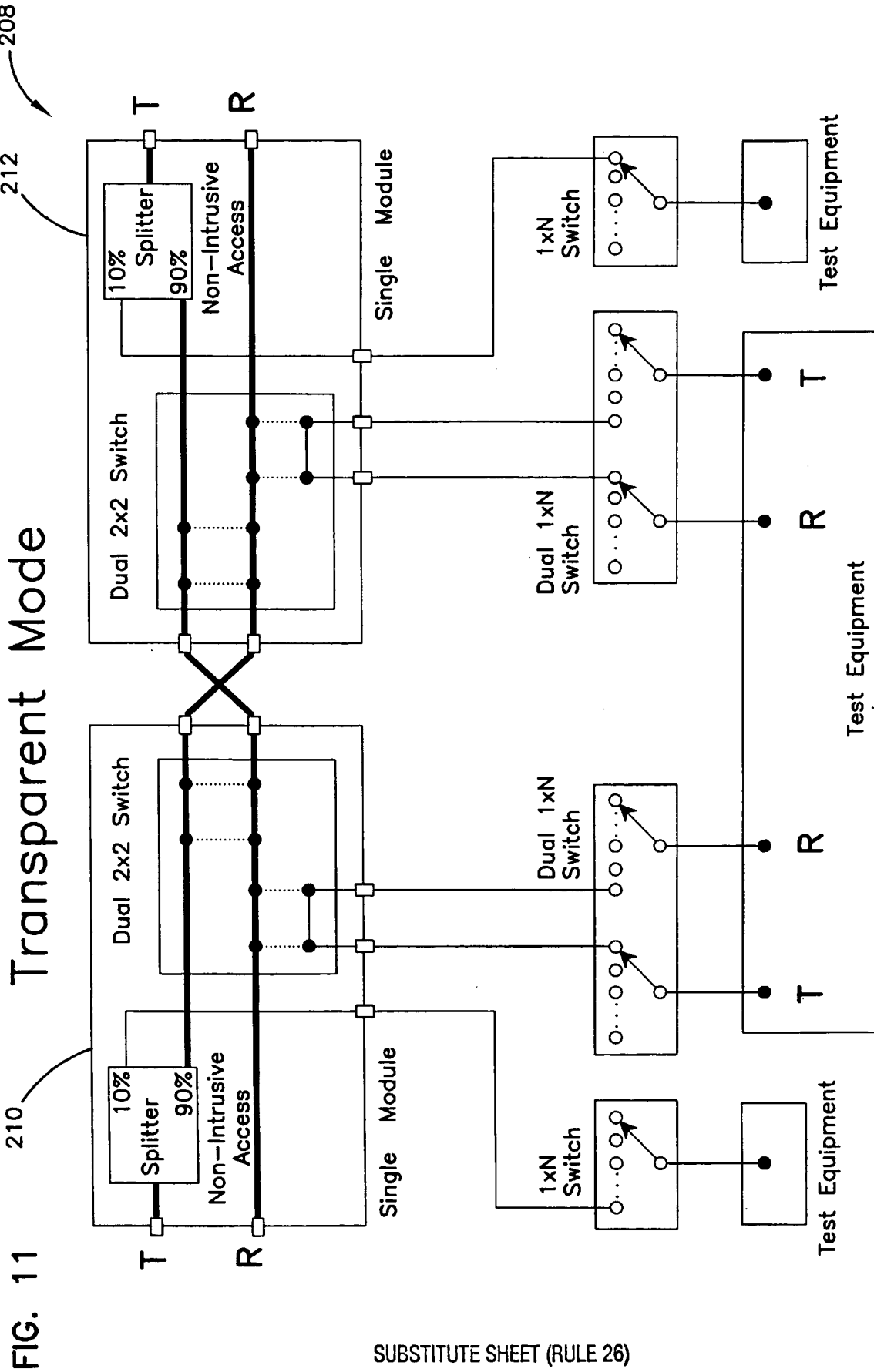
FIG. 8

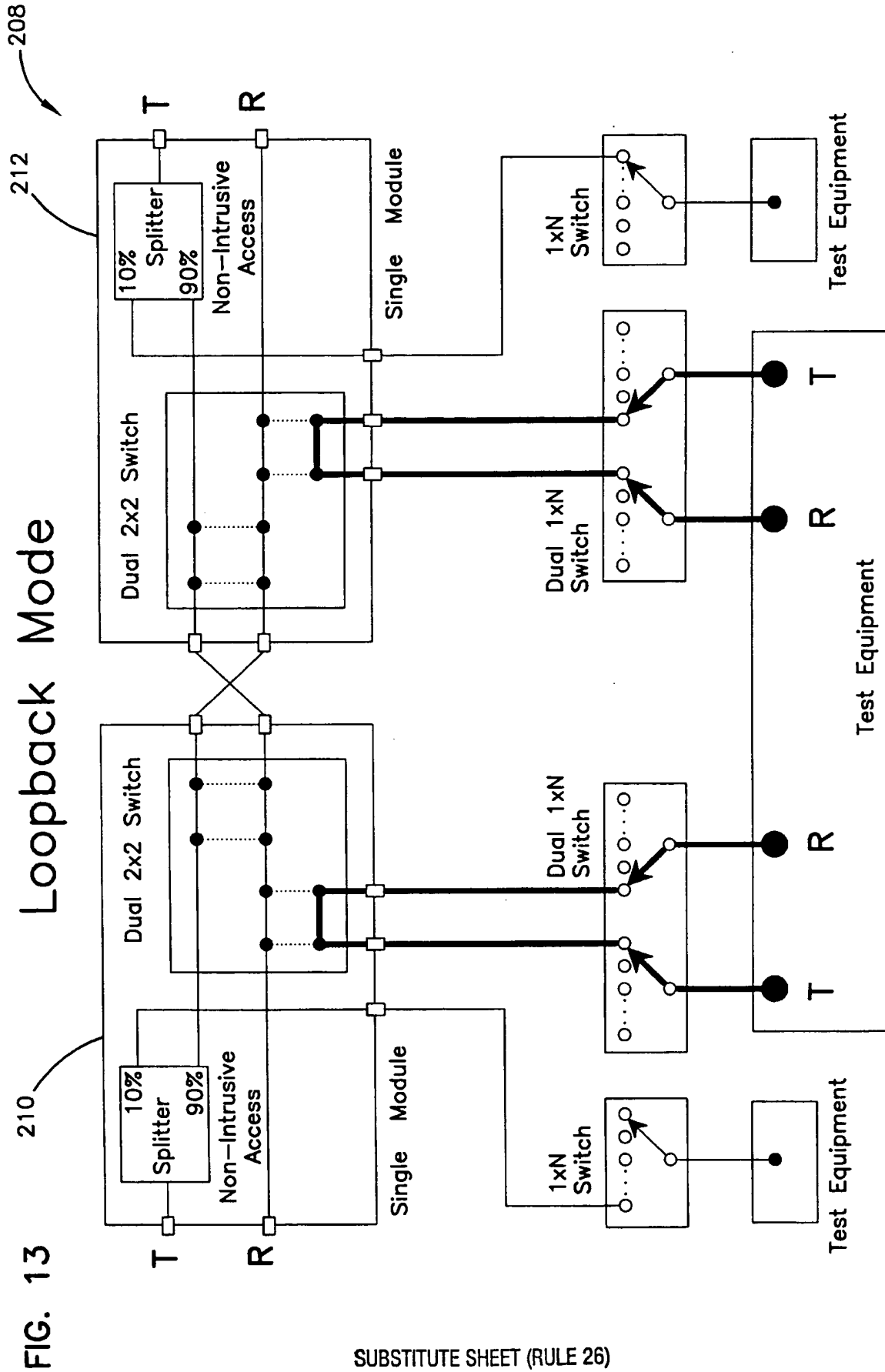
9/38

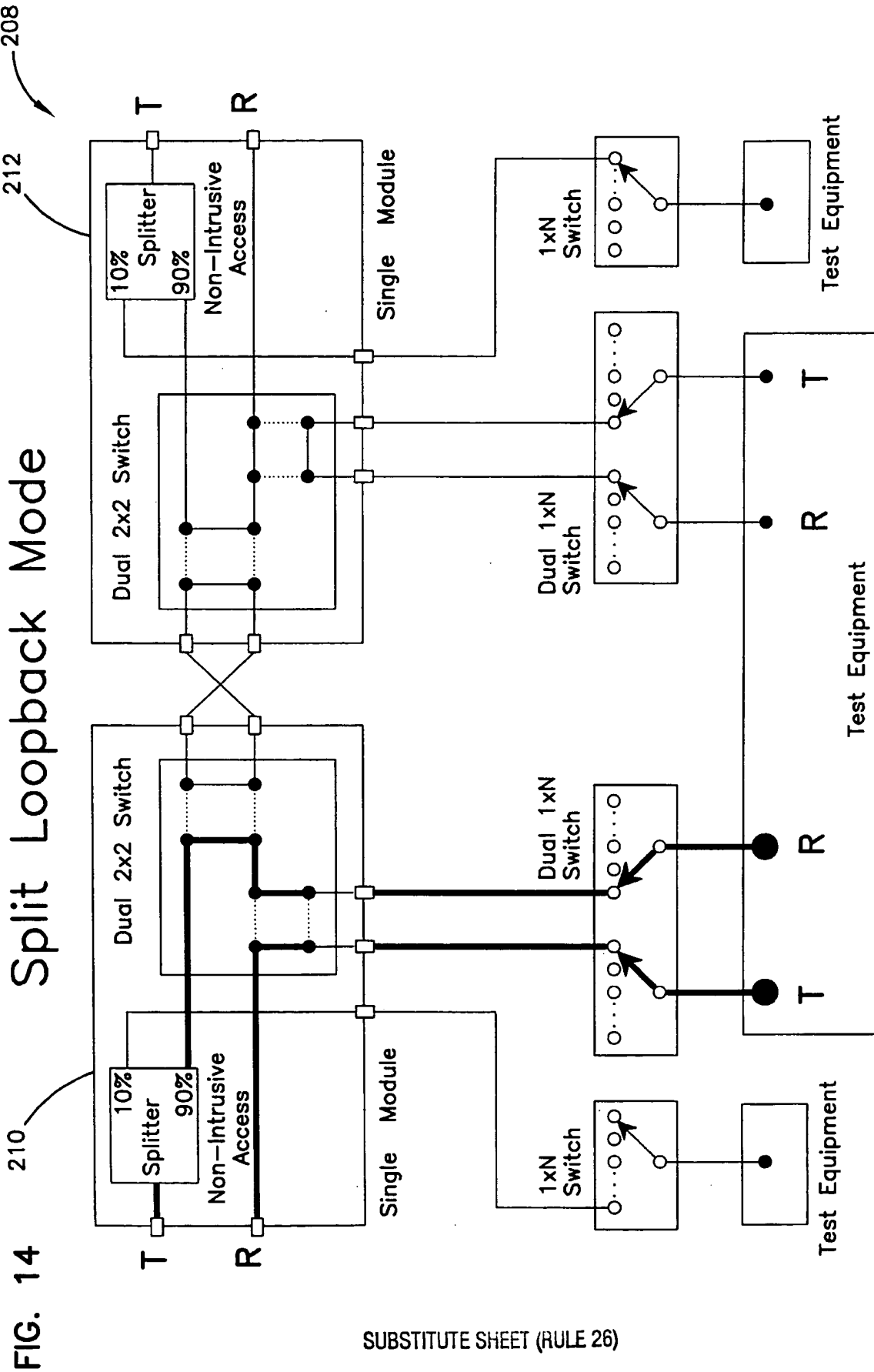
FIG. 9

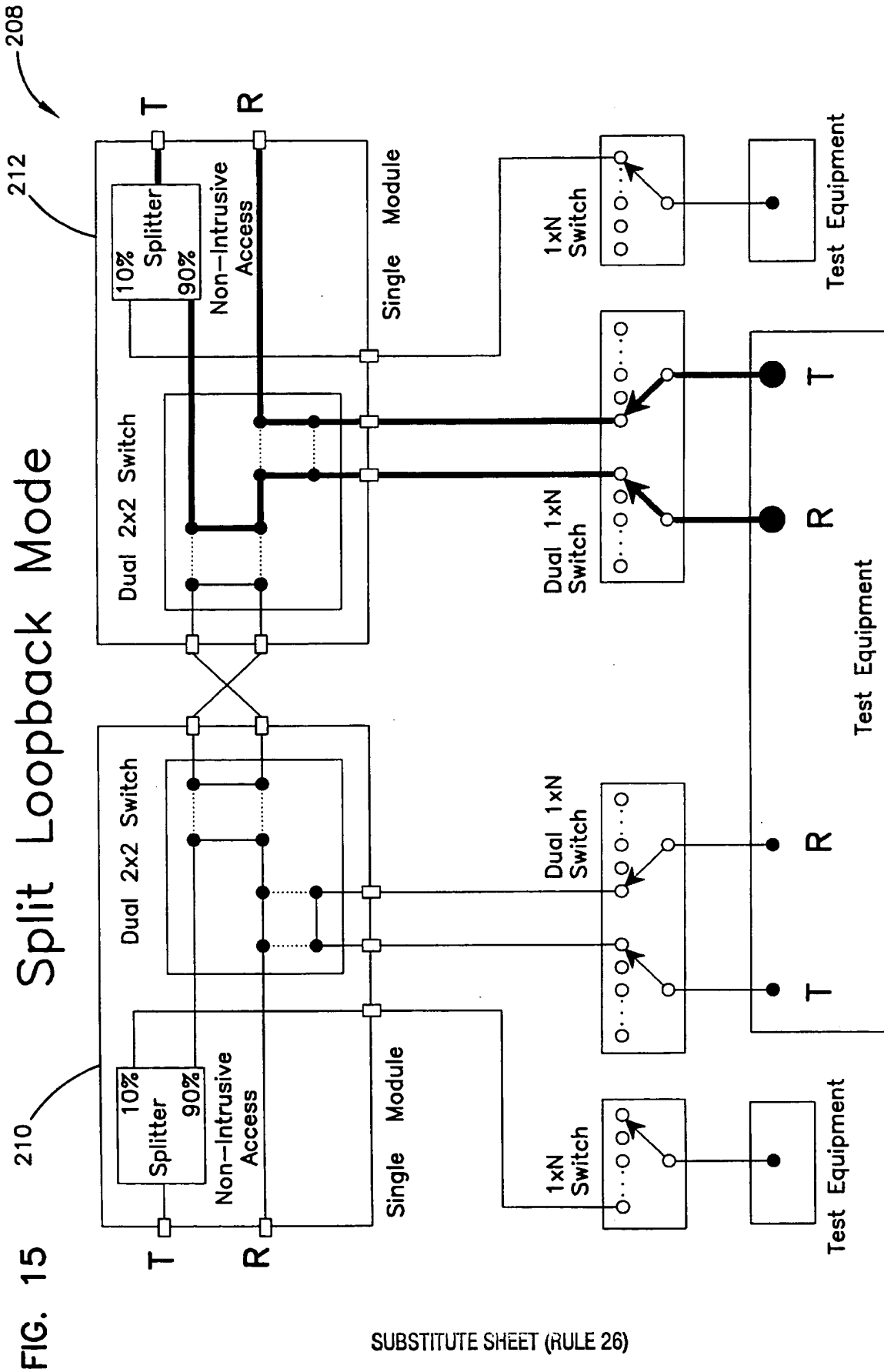


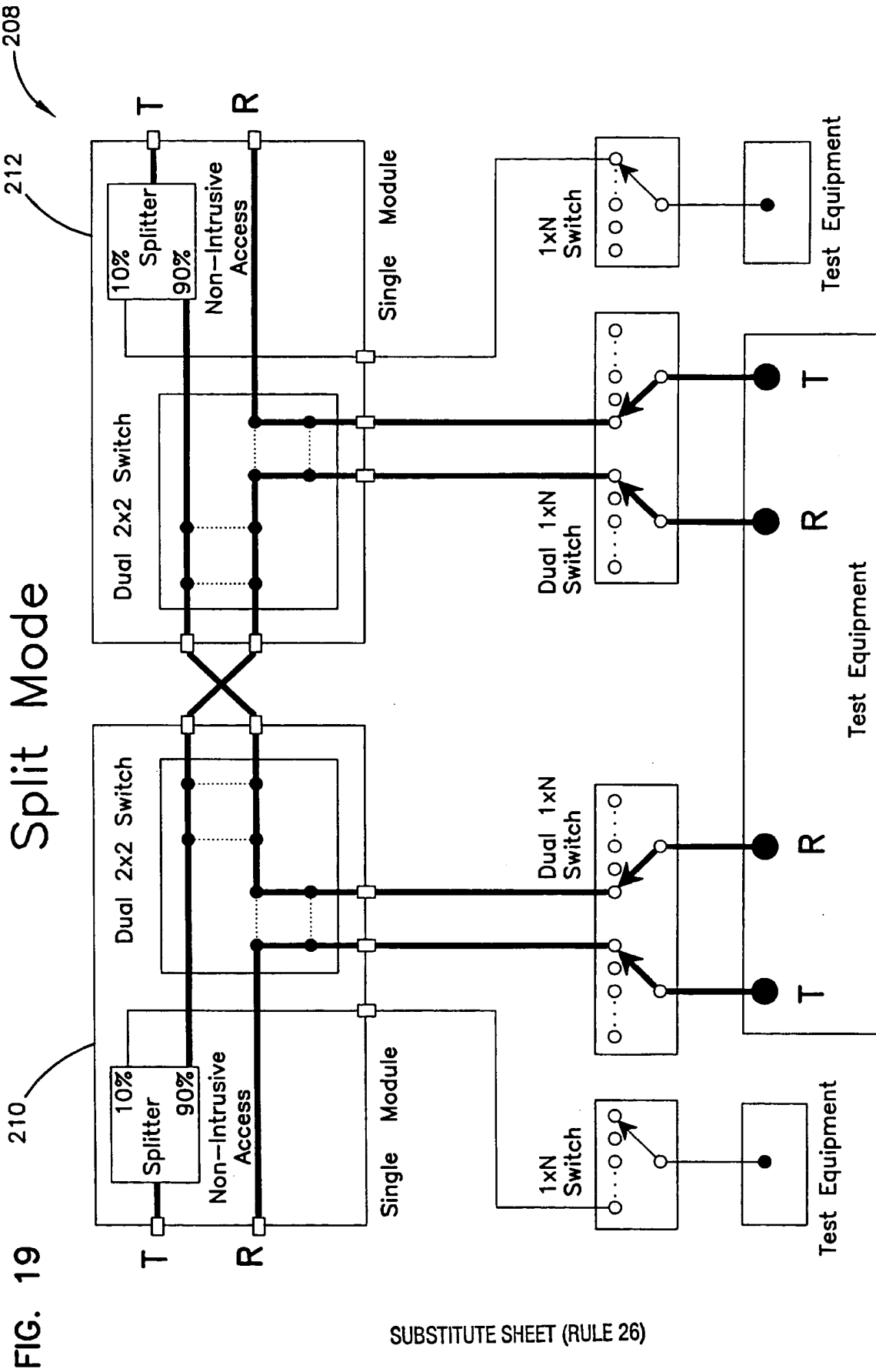












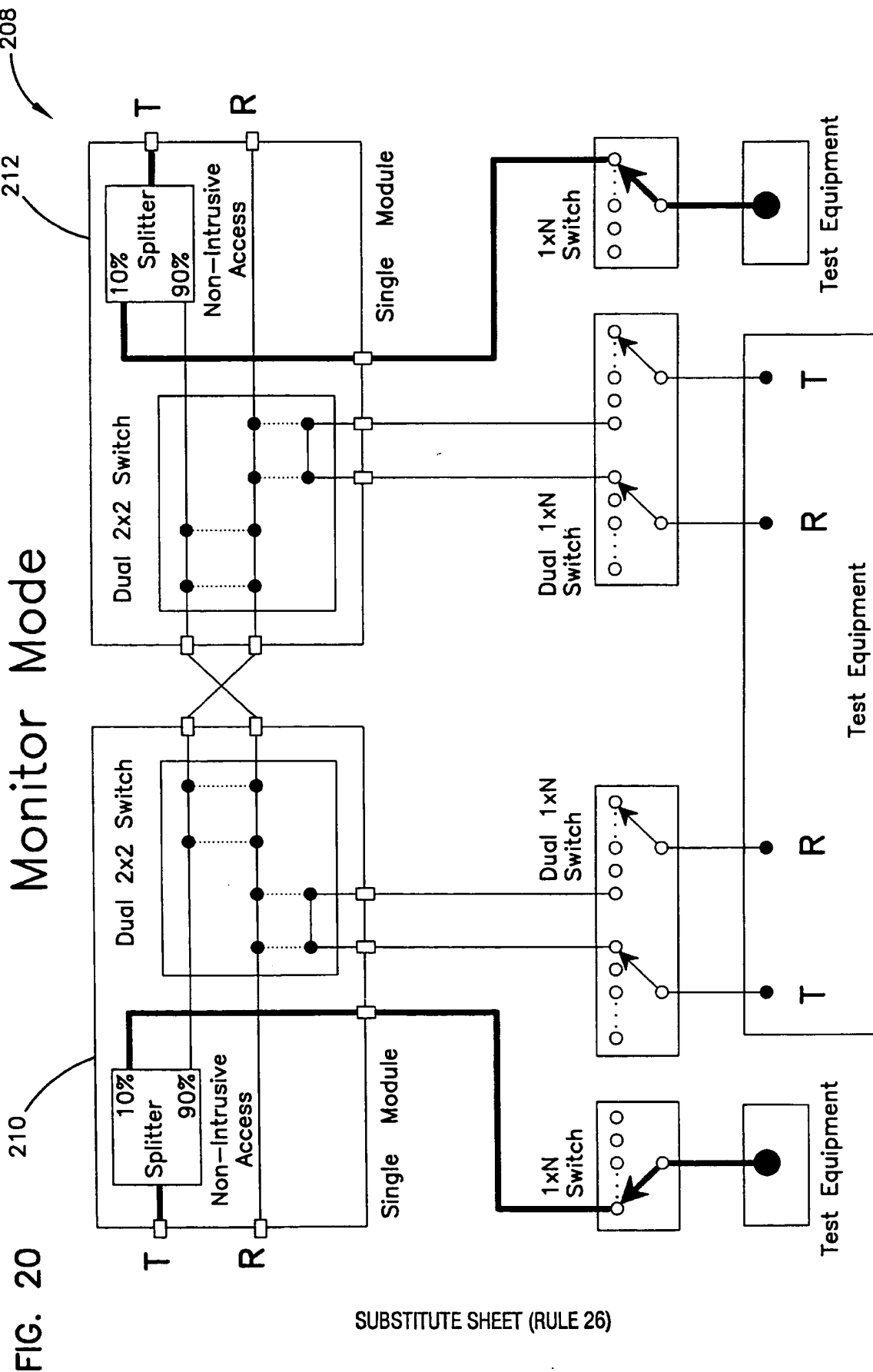


FIG. 21

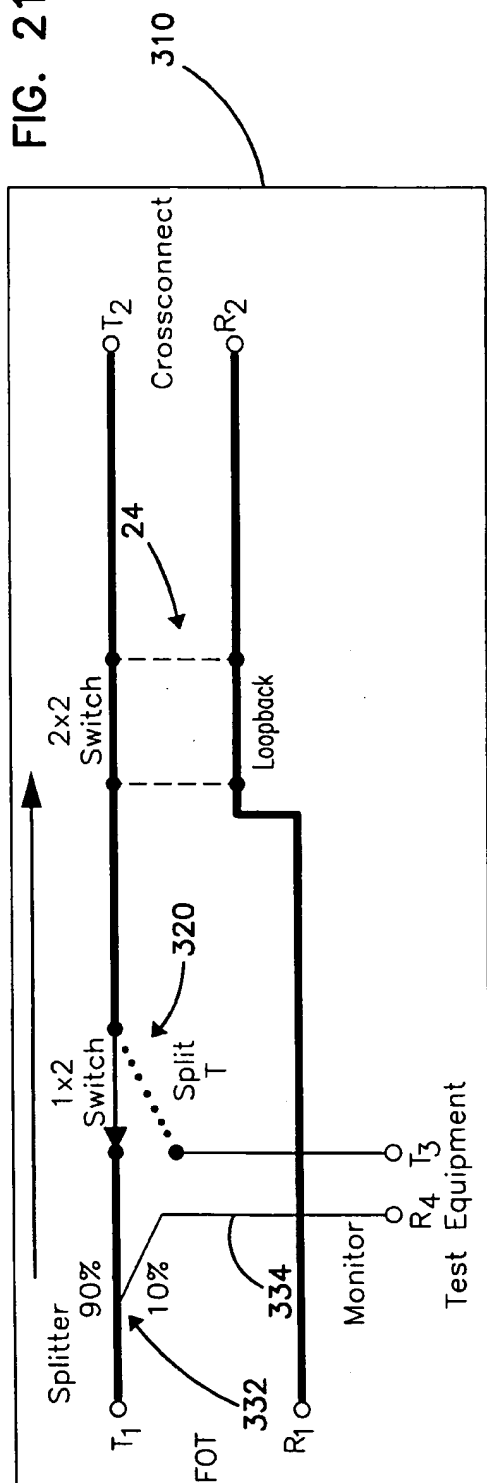


FIG. 22

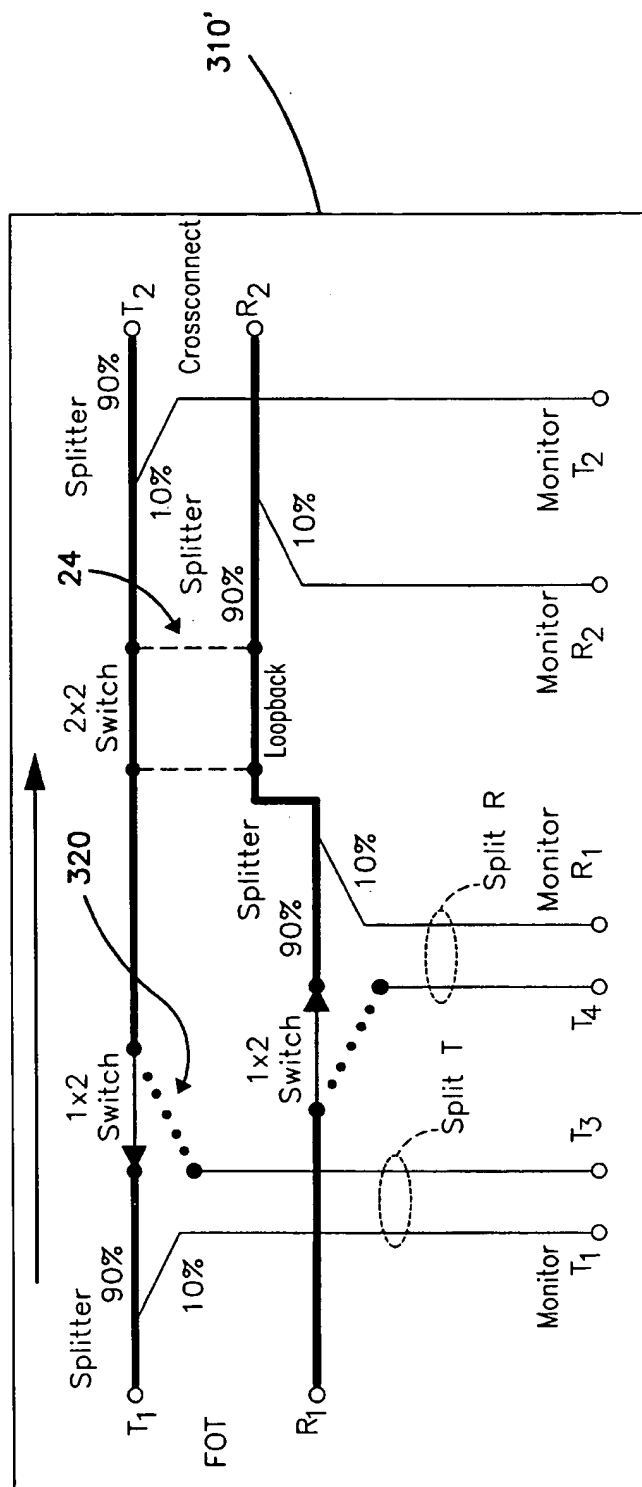


FIG. 23

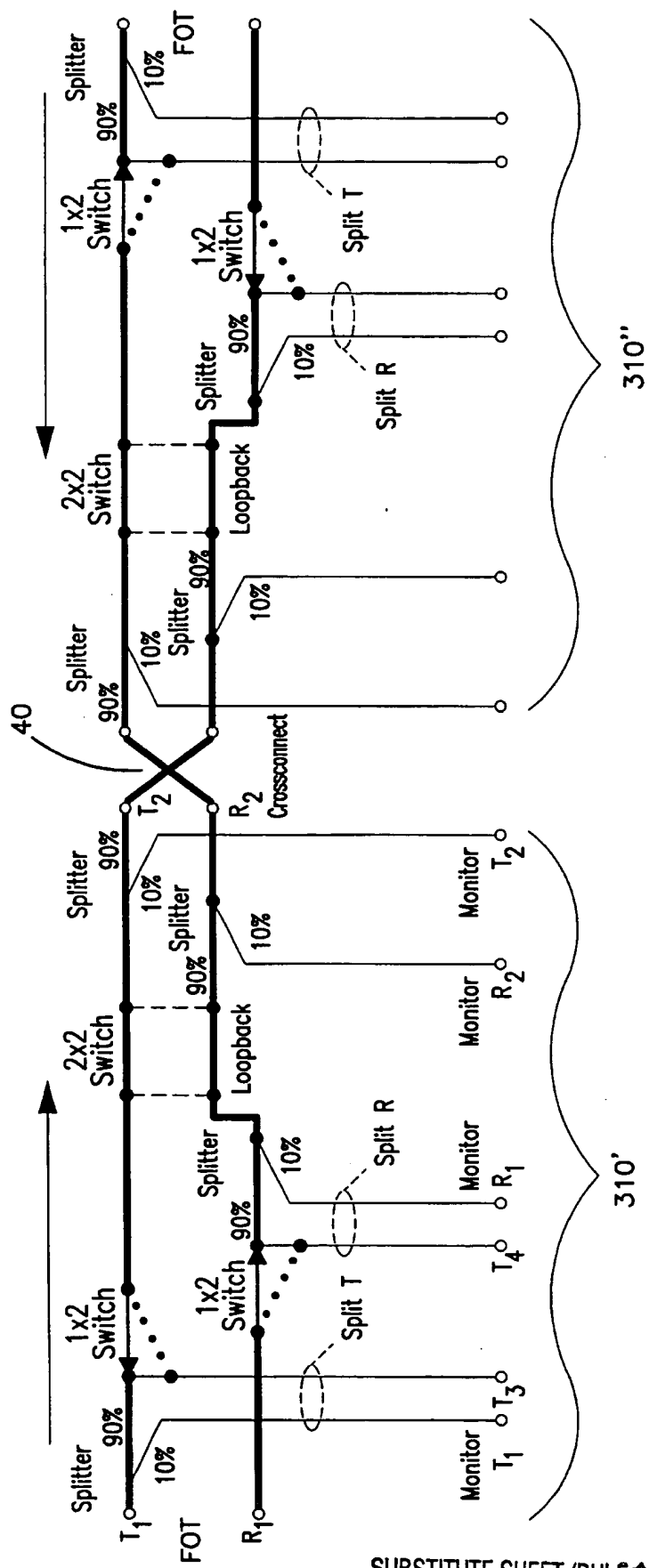


FIG. 24

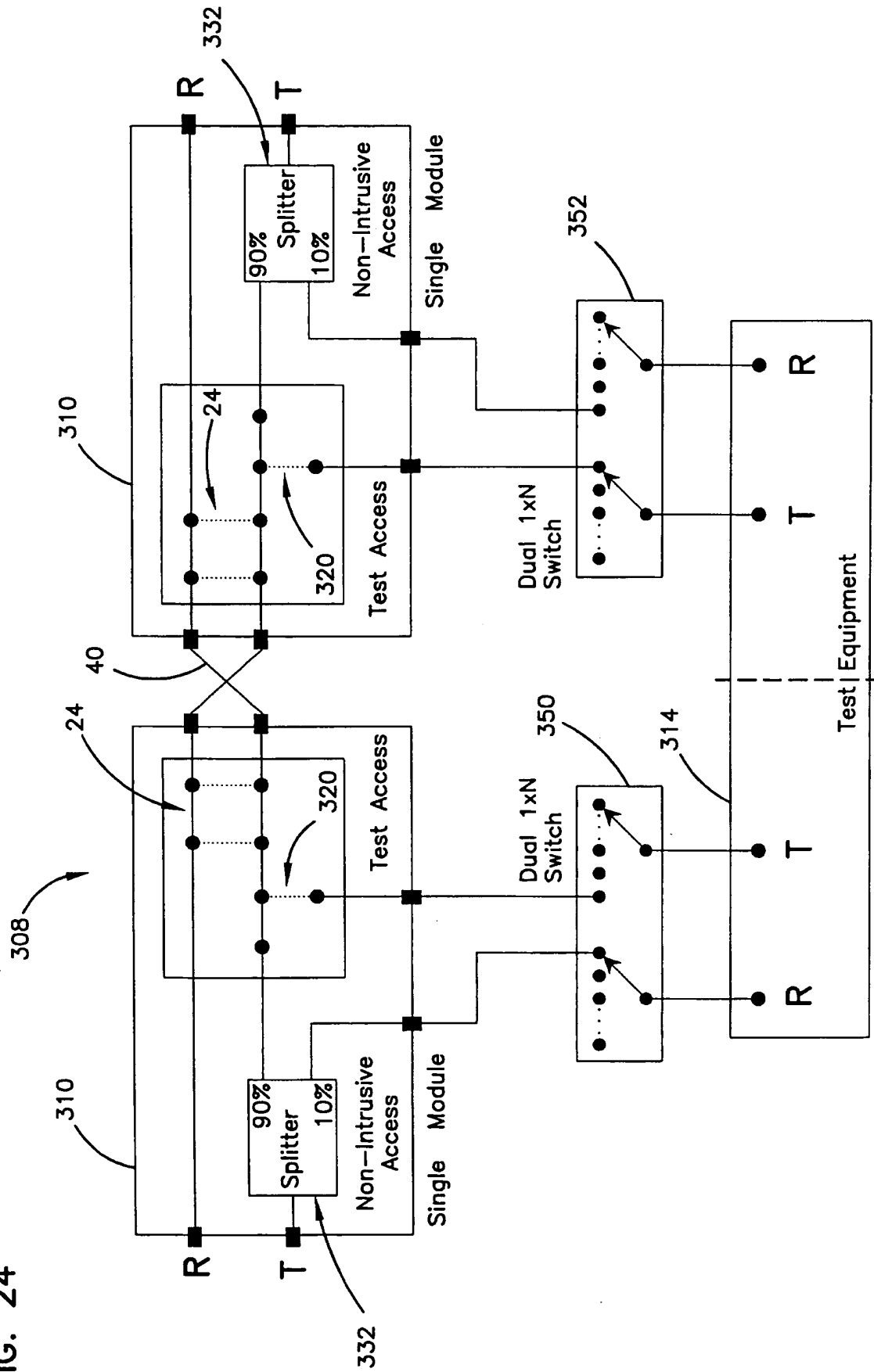
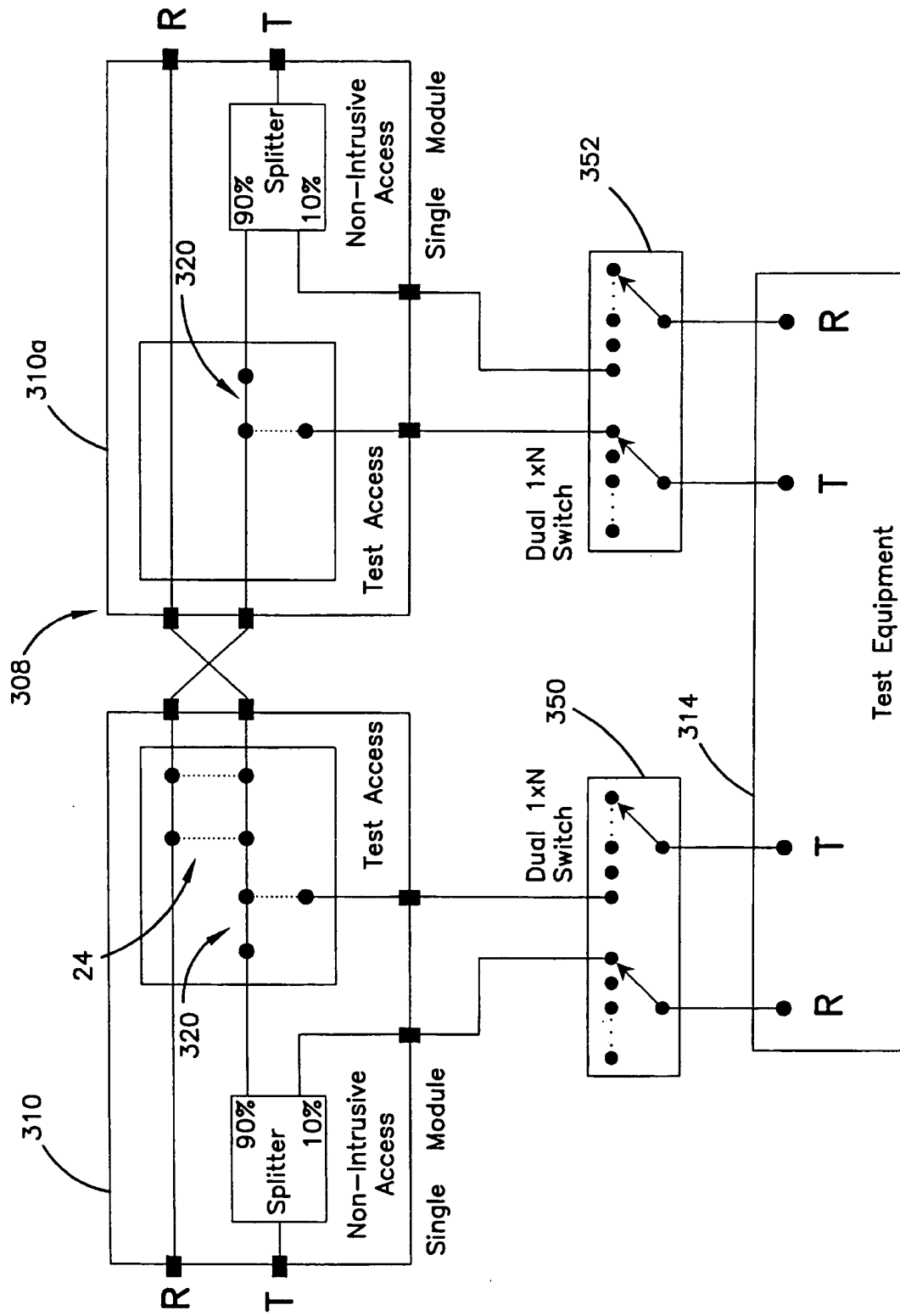


FIG. 25



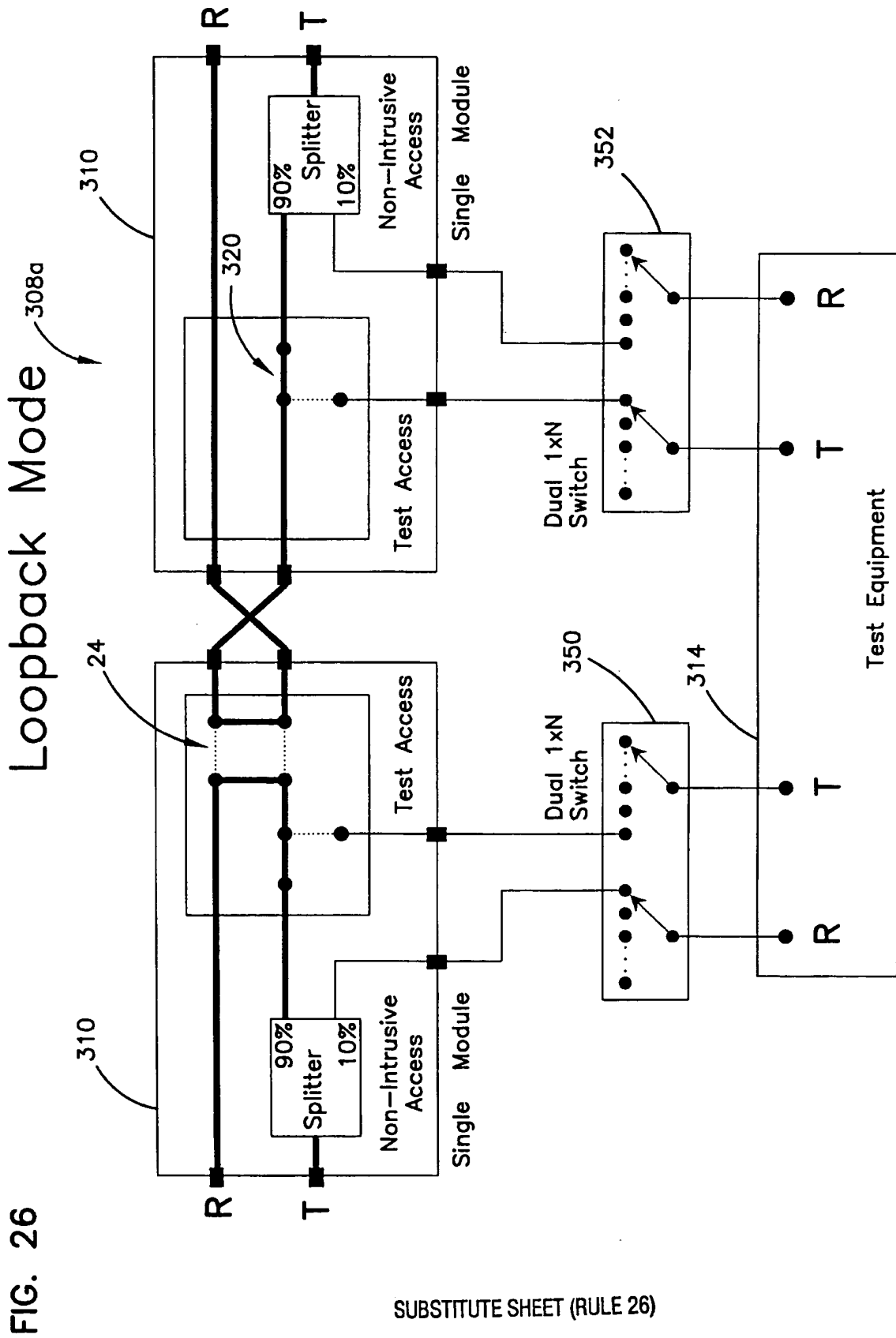


FIG. 27

Split Loopback Mode

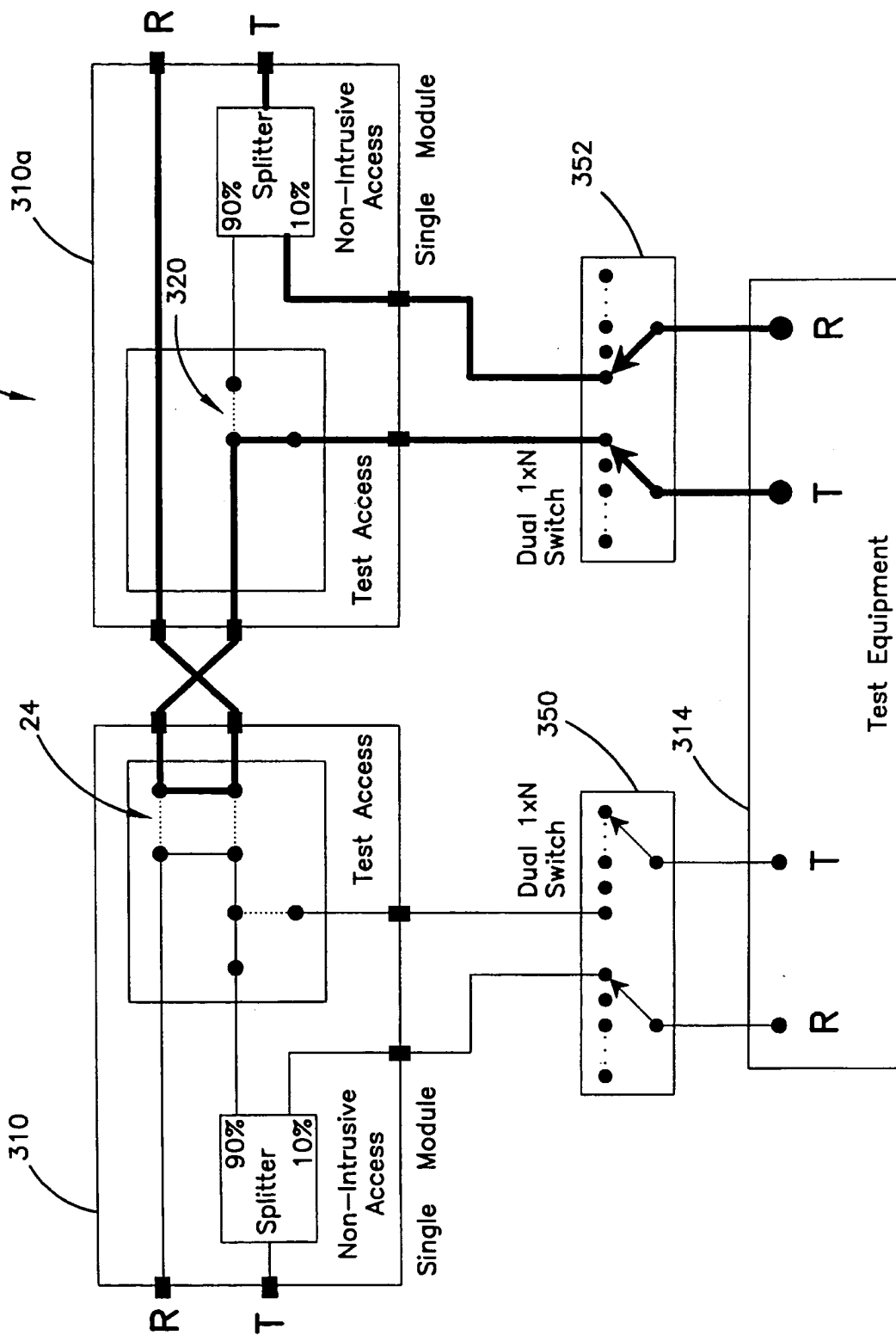


FIG. 28

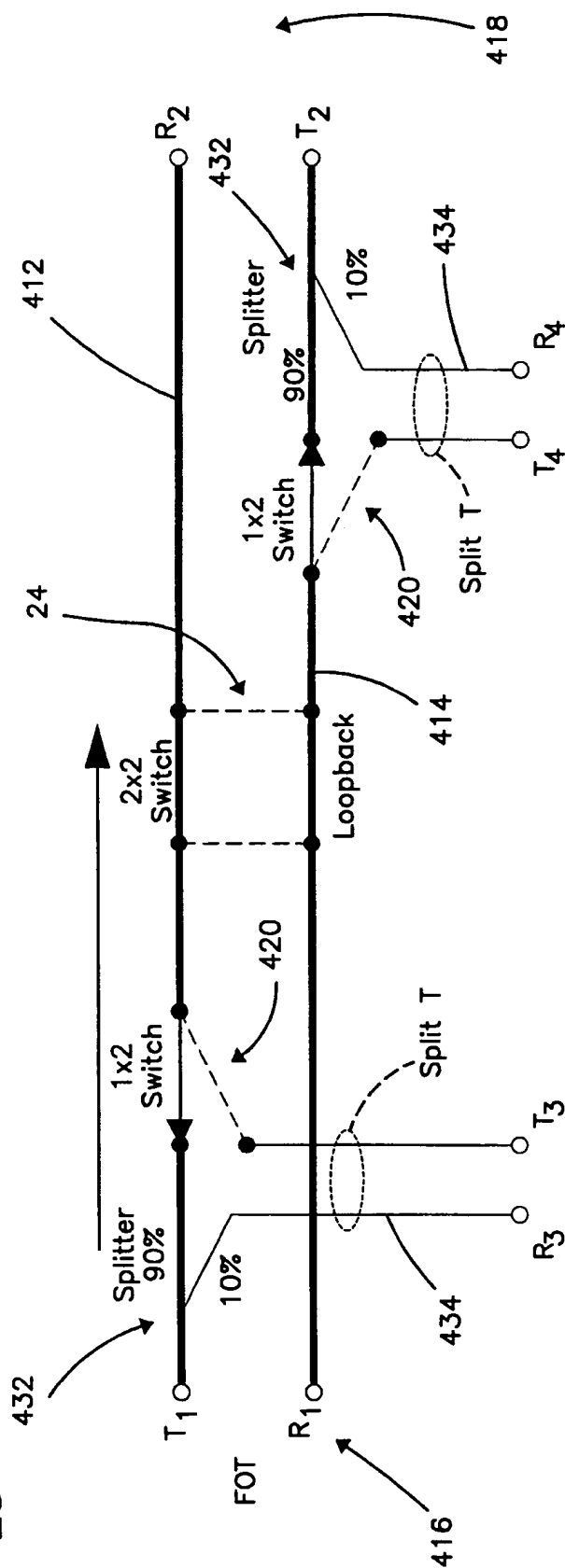
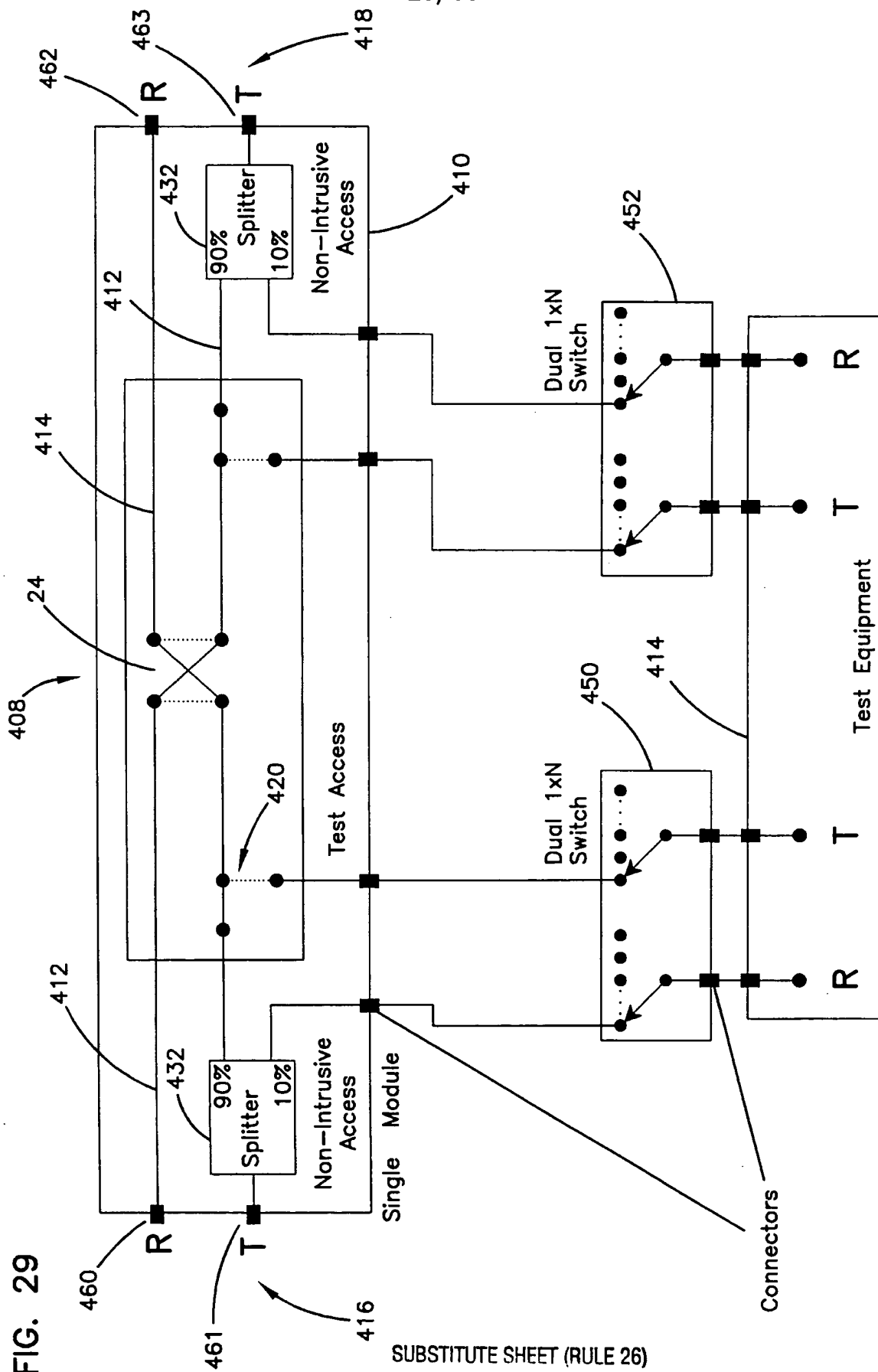
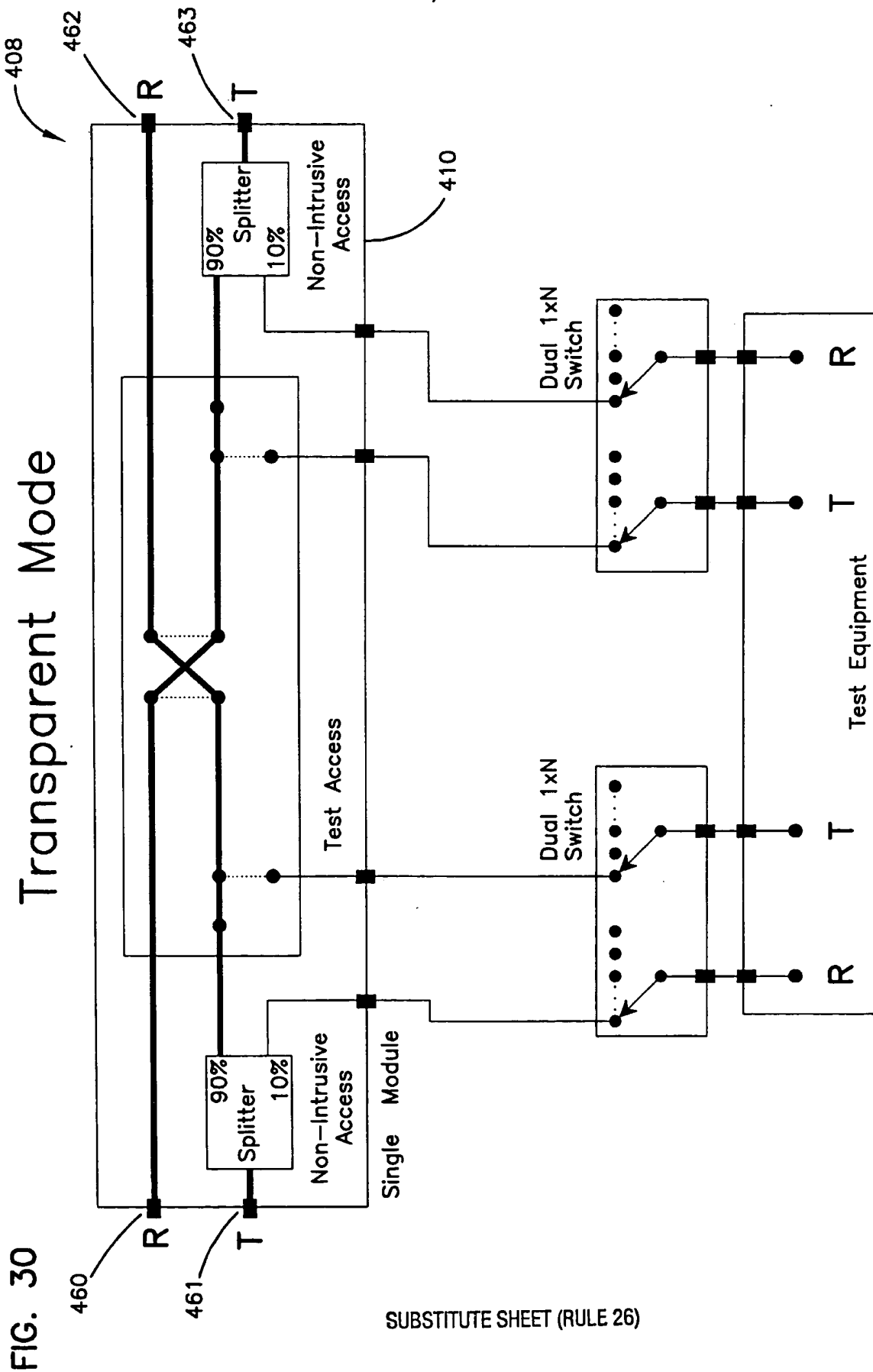


FIG. 29





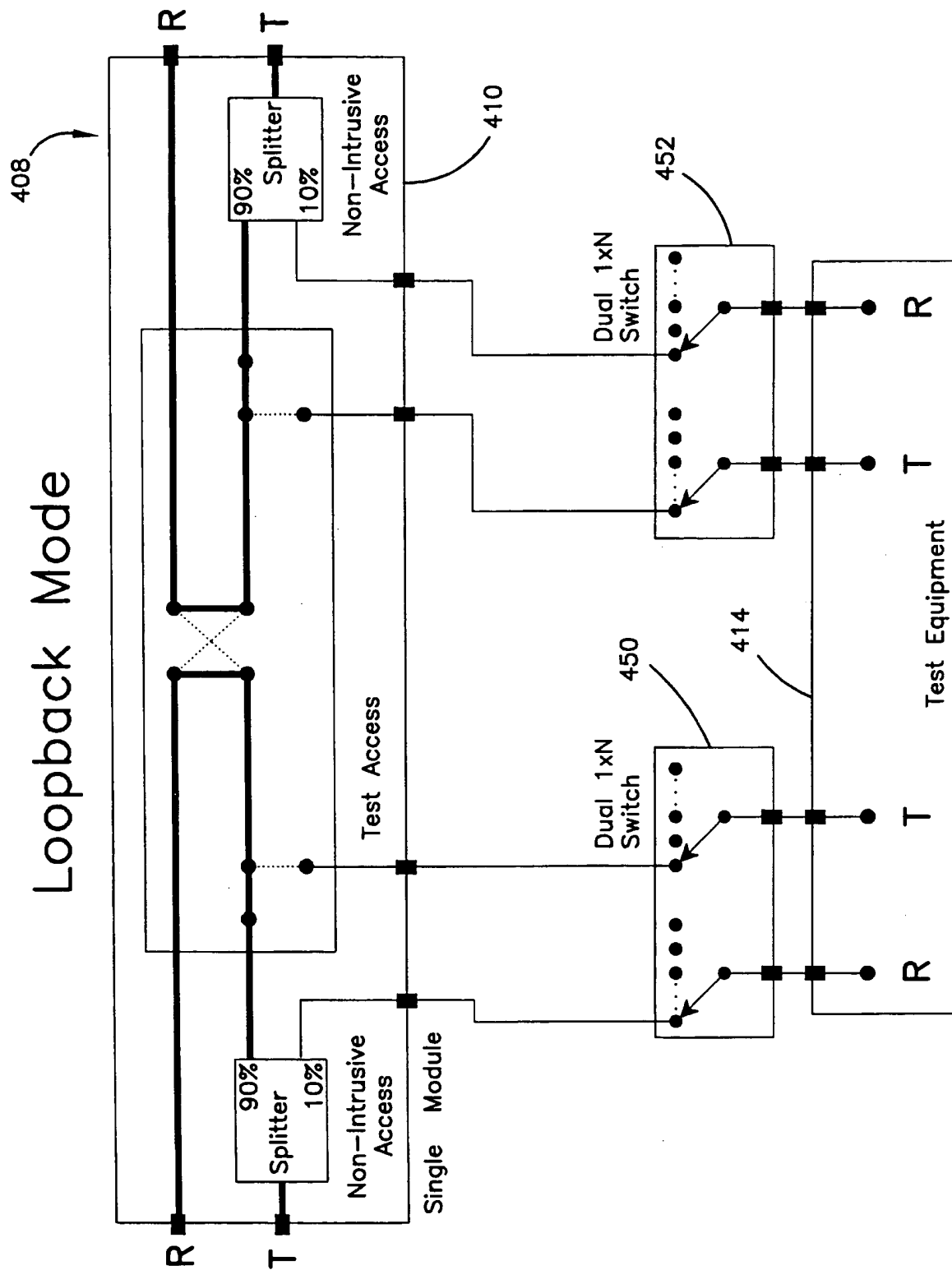
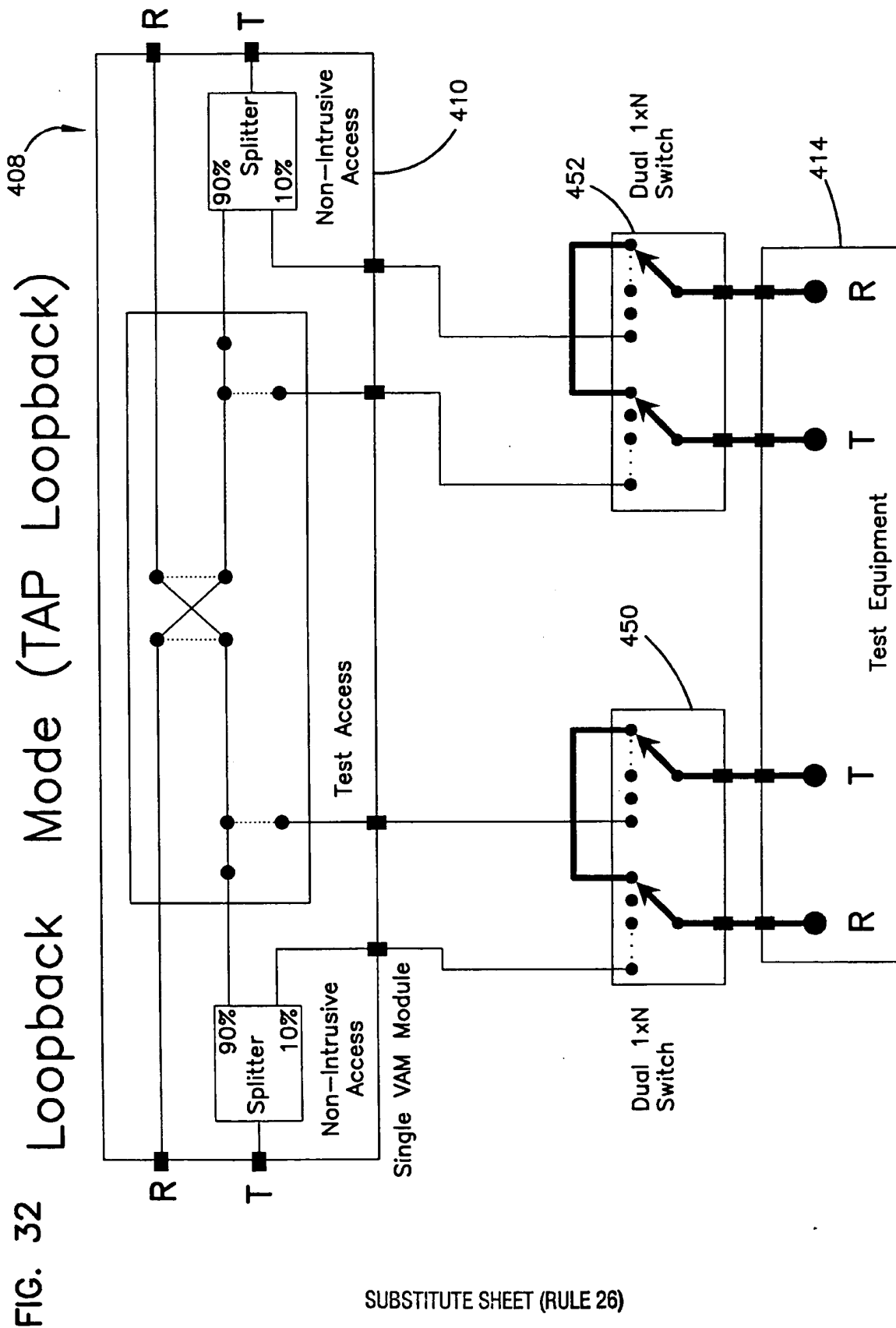


FIG. 31



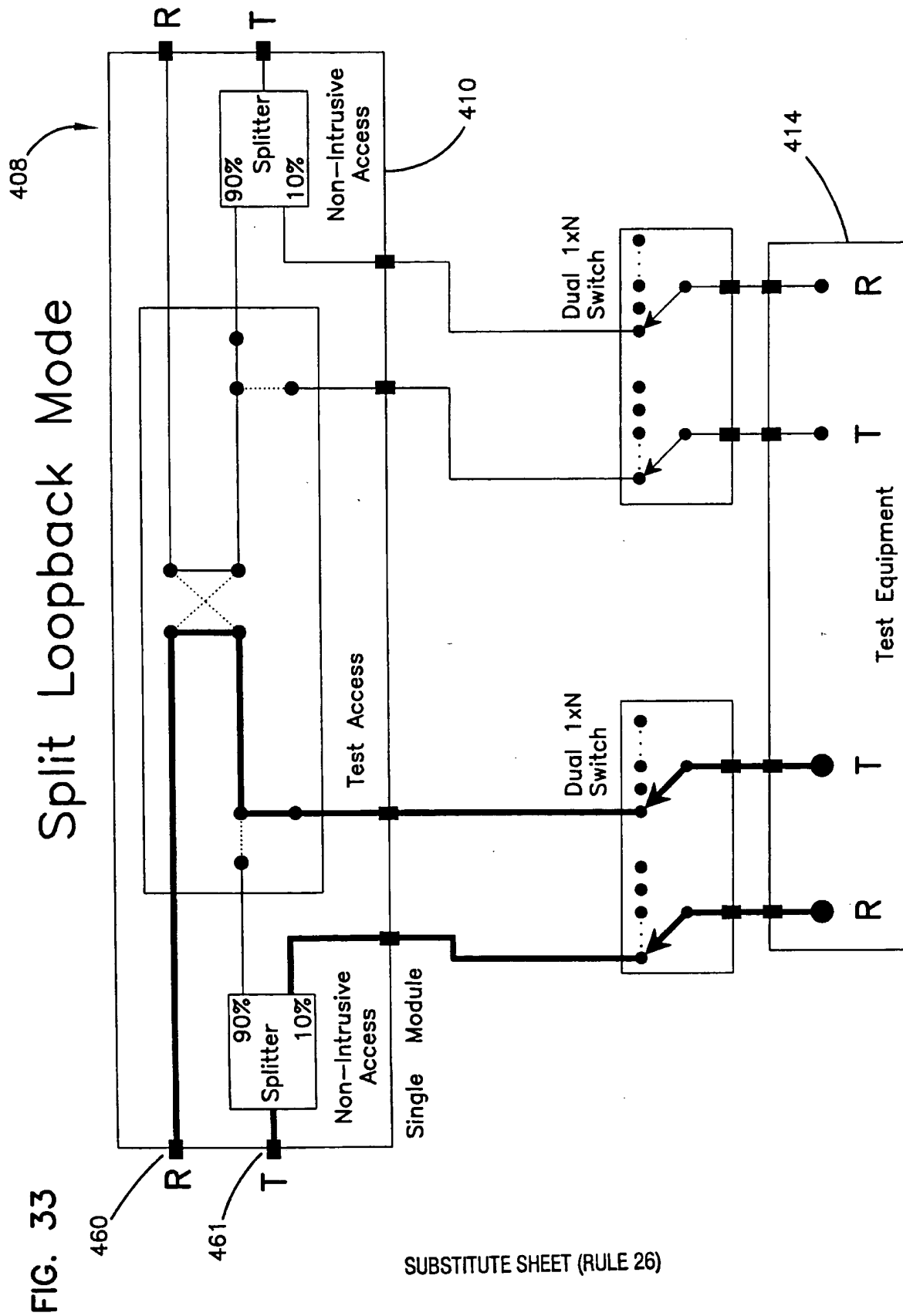
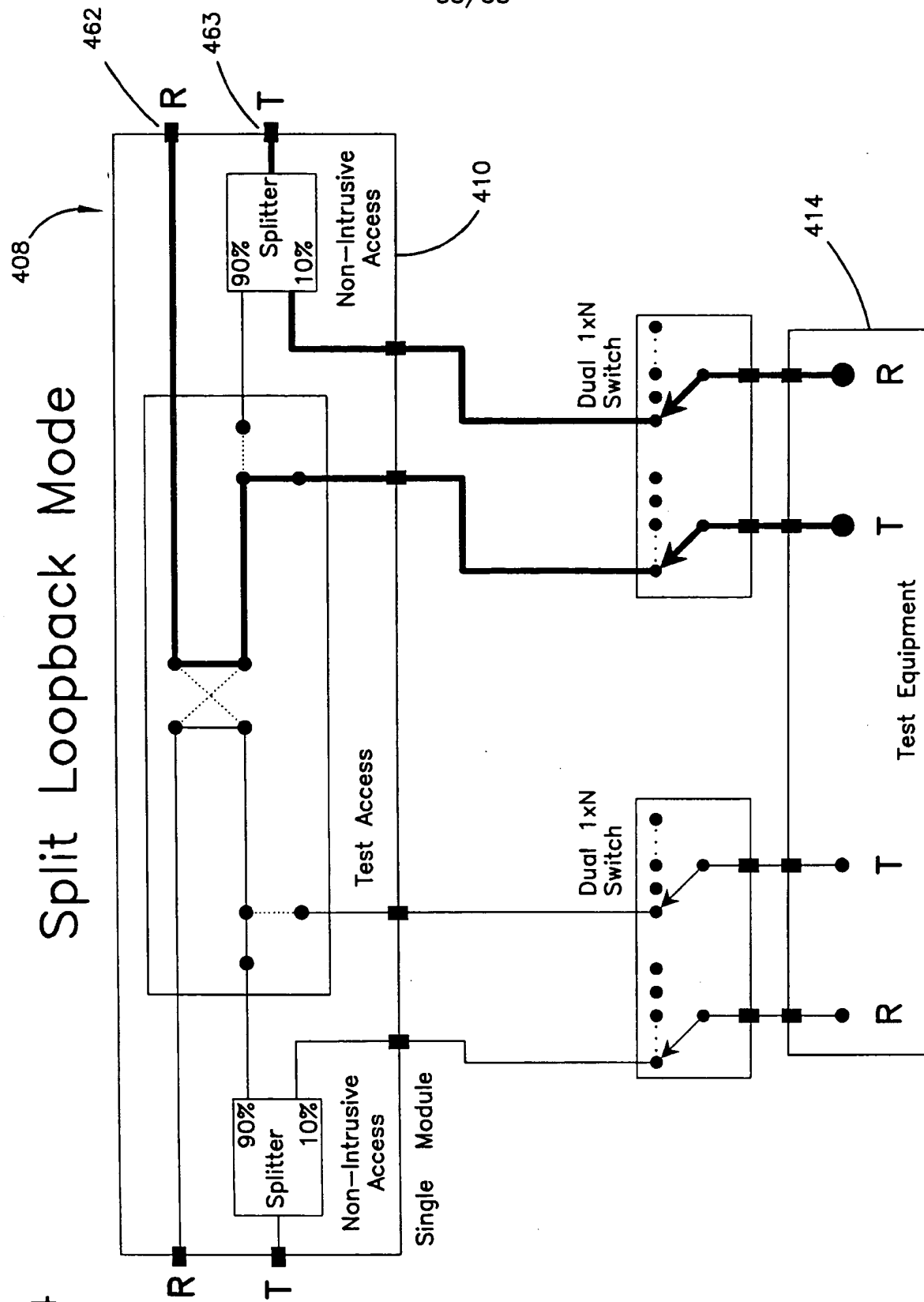


FIG. 34

Split Loopback Mode



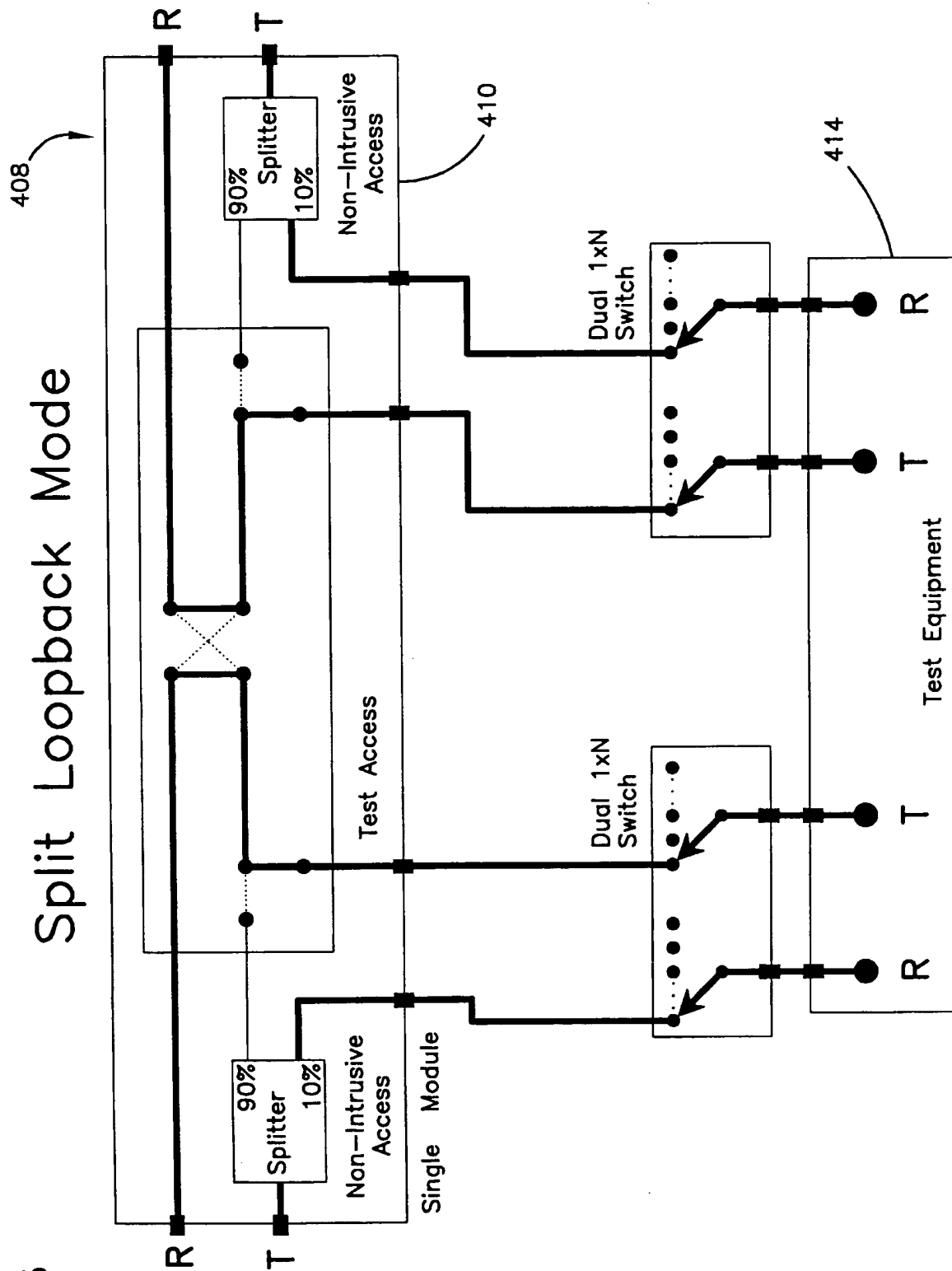
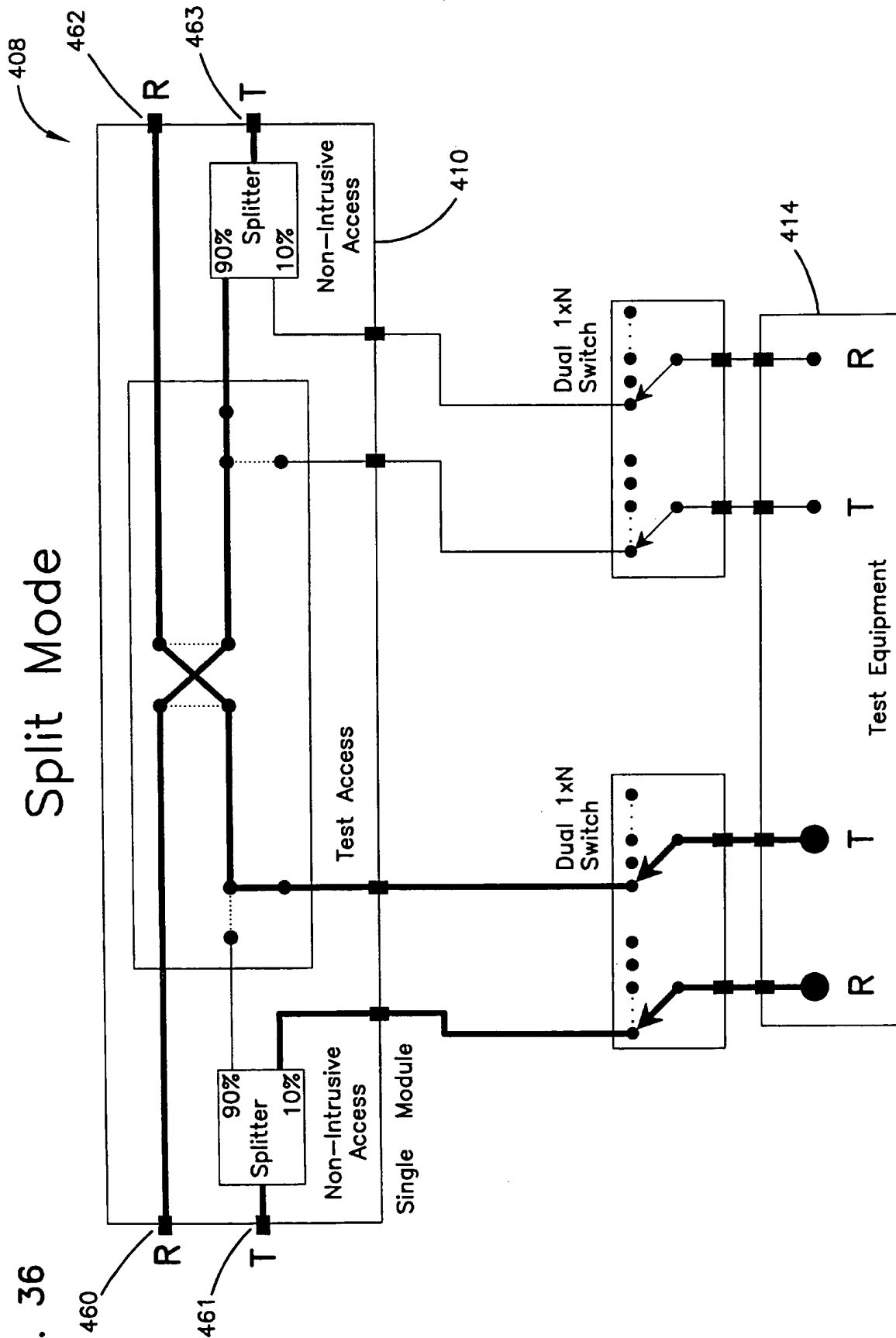
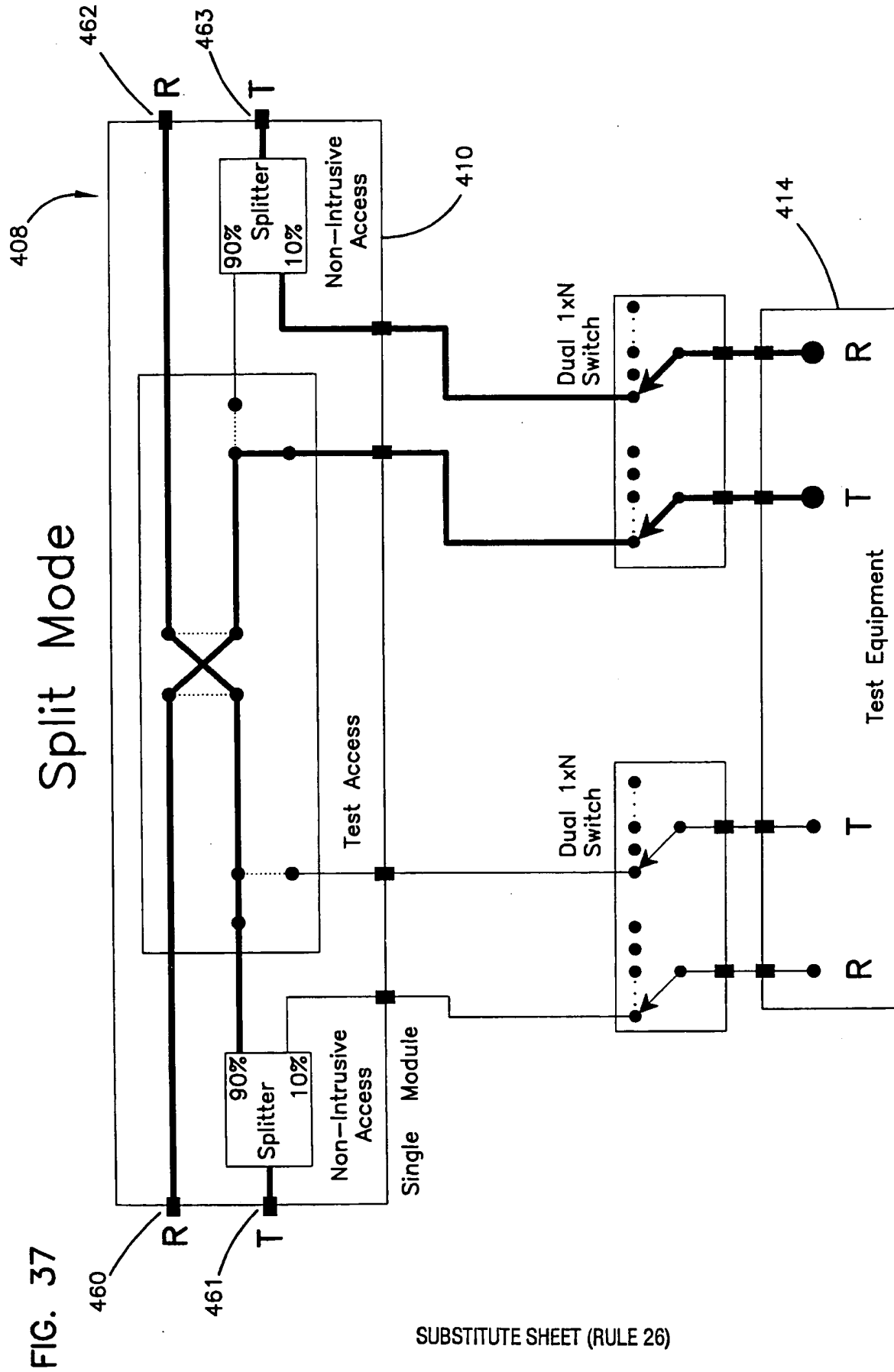


FIG. 35

Split Mode

FIG. 36





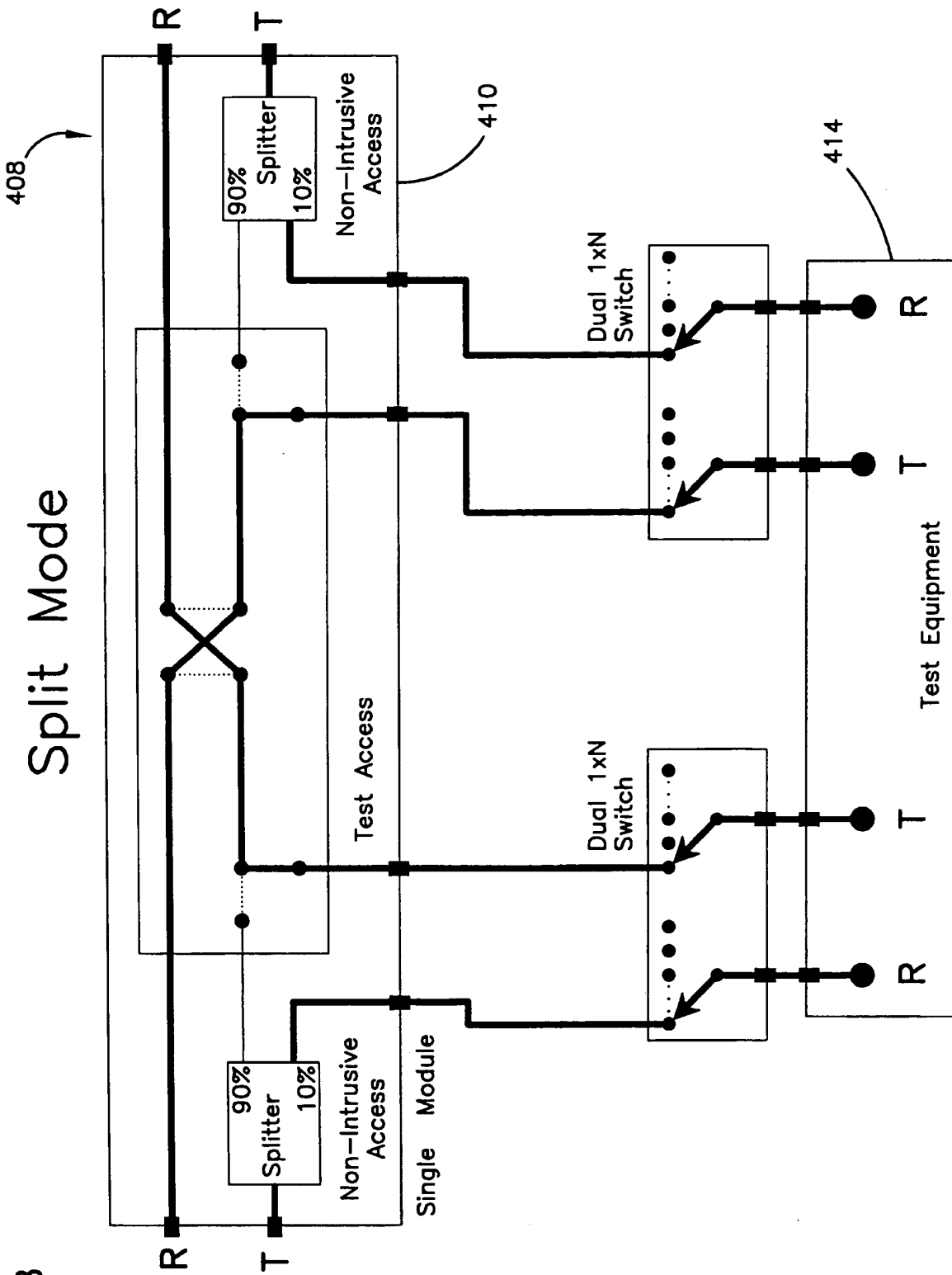


FIG. 38

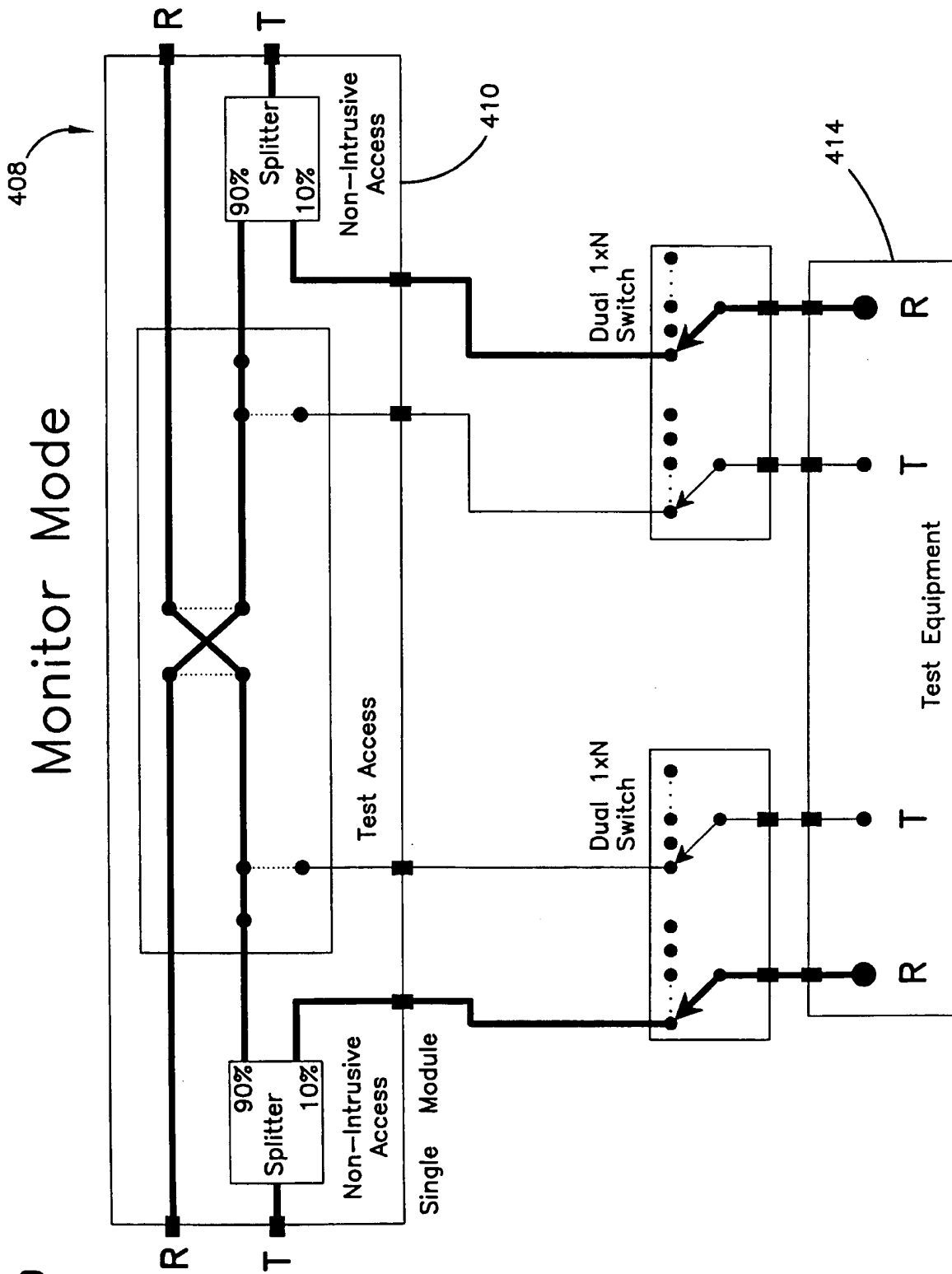


FIG. 39

INTERNATIONAL SEARCH REPORT

Int. .onal Application No

PCT/US 00/17113

A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 H04Q11/00 H04B10/08

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 H04Q H04B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X A	WO 97 01897 A (MERLI STEFANO ;ANDREOZZI PAOLO (IT); NORBIATO RENATO (IT); TESTA F) 16 January 1997 (1997-01-16) figure 2	1-3,7,9, 14,16, 21,26, 41,46 4-6,8, 10-13, 15, 17-20, 22-25, 27-40, 42-45,47
X A	US 4 887 309 A (GRANESTRAND PER O ET AL) 12 December 1989 (1989-12-12) figure 2 --- -/--	1 2-47



Further documents are listed in the continuation of box C.



Patent family members are listed in annex.

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Date of the actual completion of the international search

13 October 2000

Date of mailing of the international search report

20/10/2000

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INTERNATIONAL SEARCH REPORT

Int. Patent Application No.

PCT/US 00/17113

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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A	US 5 774 245 A (BAKER PHILLIP E) 30 June 1998 (1998-06-30) figure 5 ---	1-47
A	US 5 432 875 A (KORKOWSKI JEFF L ET AL) 11 July 1995 (1995-07-11) cited in the application the whole document -----	1-47

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